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ANNUAL REPORT

OF

THE PENNSYLVANIA STATE COLLEGE

For the year 1905-1906.

From July 1, 1905, to June 30, 1906.

PART I—DEPARTMENTS OF INSTRUCTION.
PART II—AGRICULTURAL EXPERIMENT STATION.

HARRISBURG, PA.:
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REPORT

OF

The Pennsylvania State College

FOR THE YEAR 1905-1906.

Harrisburg, Pa., June 30, 1906.

To the Senate and House of Representatives of the Commonwealth of Pennsylvania:

I have the honor herewith to transmit the Treasurer's report of the receipts and expenditures of The Pennsylvania State College, for the year 1905-1906, as required by law; and, in connection therewith, the reports of the professors in charge of the departments of instruction. I venture to call attention to these reports as containing matter of great interest to the people of the Commonwealth.

JAMES A. BEAVER,
President of the Board of Trustees.

I.—AGRICULTURE.

(a) GENERAL.

To the President:

Sir: I have the honor to transmit herewith the report of the Department of Agriculture for the present fiscal year. The work of this Department has undergone few changes during the past year as regards the instruction given to the students of the four years' course. The appointment of Professor H. E. Van Norman as head of the Dairy Department has relieved the Agricultural Department of the dairy work, which for several years has been under the direction of the Professor of Agriculture. This is a most important appointment and will be greatly to the advantage of the Dairy as well as the Agricultural Department.

During the past year 12 students have pursued special work in agriculture and have been at a considerable disadvantage because the College does not prescribe a special course of one or two years. In some instances it has been found almost impossible to provide a satisfactory schedule for these men. Some prospective students, who have been unable to receive positive assurance on account of the difficulty in securing a desired schedule, have pursued studies elsewhere. The number of men applying for special work at The Pennsylvania State College fully warrants the establishment of prescribed courses. I would most heartily recommend that such courses be established.

Since the re-establishment of the Short Course in Agriculture it has been impossible for the permanent instructors in the Department to give satisfactory instruction to students in this course and to properly attend to their other College duties. During the past four years temporary instructors have been secured for the Short Course term only. While these men have come to us with an earnest desire to do their best, yet, as some of them were wholly unacquainted with this class of teaching, they were not prepared to give the most efficient service. A permanent instructor, who would be able to devote all his time to Short Course work, would be able to give more efficient instruction and place the Short Course on a more satisfactory footing. Heretofore the various divisions of the School of Agriculture have offered instruction in the Short Course along various lines of work. Many of the Short Course students have found it difficult to select from the studies offered those which they most desire to pursue. In many instances it was impossible to arrange satisfactory schedules for all students. To meet this difficulty, which obviously must increase with the increasing number of students, I would recommend that, instead of permitting Short

Course students to select the studies that they desire to pursue, the College offer prescribed courses of study. To illustrate: One course to pertain chiefly to Agronomy, another to pertain largely to the production and feeding of farm animals, another to pertain largely to Horticulture, and still another to Farm Dairying. I would most heartily recommend that a few prescribed courses be offered instead of the list of subjects from which students may be permitted to select as at present. During the present year 27 students pursued the studies of the Short Course in Agriculture.

The Correspondence Courses continue to be popular with the agriculturists of Pennsylvania who desire to study agriculture and yet for various reasons cannot attend college. The steady enrollment of new students each year attests to the value of these studies to the practical farmers of Pennsylvania. On account of pressure of other College work the Correspondence Courses have not received the attention which they deserve. Nothwithstanding this fact, from 500 to 700 new students enroll each year. From actual count, it has been ascertained that about 60 per cent. of the students who enroll average the satisfactory study of three courses. This also may show the appreciation of this work by those who are actively engaged in agricultural pursuits. While some of the students are not actively engaged in agricultural work, yet all are interestd in agriculture and most of the students are practical men engaged in farming. The total enrollment in the Correspondence Courses at the present time numbers 3,980. The most urgent need of the Correspondence Course work at the present time is an assistant who would be able to give all of his time to this work. The College, on account of the increased number of students both in the resident courses and in the Correspondence Courses, has been unable to properly attend to the Correspondence Course work. Notwithstanding this neglect, the Courses continue to be more popular than ever.

During the past year the Experiment Station has greatly increased its facilities for rearing and maintaining poultry for experimental purposes. This affords the College greater advantages in the way of furnishing illustrative material for educational purposes. The fowls of the Experiment Station are available for educational purposes, provided experiments are not interfered with. During the past year a new incubator building and a number of poultry houses, which afford facilities for giving instruction not only in judgment but in operating incubators and brooders as well, have been constructed.

The Department stands greatly in need of pure bred stock that could be used as illustrative material for purely educational purposes. The College now maintains representatives of three pure breeds of cattle. One of these, however, is represented by only one animal. The Department stands greatly in need of other animals that can be used for class illustration. Unfortunately there are comparatively few herds of pure bred stock that can be visited at suitable times within easy reach of classes of students. Consequently, if Animal Husbandry is to be made an important part of agricultural work, it is imperative that the College should maintain a number of animals each of various breeds that could be used to good advantage for educational purposes.

During the past winter various stock breeders of Pennsylvania

have donated to the College yearling animals, mostly pure bred, that the College has undertaken to fatten for the Pittsburg Fat Stock Exhibition next fall. This may show the interest that the live stock breeders of Pennsylvania are taking in the work that the College is doing along Animal Industry lines.

If the Animal Industry work of the College is to be made most efficient and is to compare favorably with that of other institutions of adjoining states, additional animals should be purchased.

Most respectfully submitted,

G. C. WATSON,

Professor of Agriculture and Superintendent of Correspondence Courses.

State College, Pa., May 18, 1906.

(b) AGRICULTURAL CHEMISTRY.

To the President:

Sir: I have the honor to present the following brief report of the operations of the Department of Agricultural Chemistry for the College year past.

The work of the past year has differed from that of the year preceding in only a few points.

The Sophomore class came under the revised curriculum this year. In consequence, they came to the subject of Agricultural Chemistry with a better preliminary experience than that possessed by the classes of preceding years. Class-work in general chemistry, including organic chemistry, and in botany, including physiological botany, was completed by the present class during the first semester, Sophomore. The lectures of the present semester, which have dealt with the components and composition of plants and, incidentally, of animals, have been extensively revised for the purpose of giving a more advanced treatment of the subject.

The corresponding practicum has been devoted to exercises in the preparation of plant components and of commercial products derived therefrom, to the study of certain qualitative methods applicable to such materials, and the study by water-culture methods of plant requirements for mineral constituents. This practicum has, as heretofore, been conducted by M. S. McDowell, M. S., in accordance with my plans.

The practicum in Dairy Chemistry with those members of the Junior class who have chosen the dairy and agricultural chemistry divisions of the Agricultural Course, a practicum including exercises in the analysis of milk, milk products, and of fats and oils in general, was given as usual. The usual lectures and practicum in Meteorology have been given to all members of the Junior class in the Agricultural Course.

The work of this Department in relation to the Creamery Course and to the Short Course in Agriculture has the same general features as during the past two or three years. The practicum in milk testing in the former course was conducted by M. H. Pingree, B. S., who had immediate charge also of the lectures and practicums with the students in the Short Course in Agriculture.

The lectures on Dairy Chemistry to the students of the Creamery Course were delivered by myself. This year, by arrangement with Prof. Van Norman, the time allotted to these lectures has been doubled, affording the opportunity for a much more satisfactory discussion of the subject than has been possible for several years.

In addition to the instruction given to the regular classes in the College and Short Courses, I delivered a course of five lectures on "The Chemistry of the Orchard" to the State nursery inspectors. This course was arranged, with your approval, at the request of the State Economic Zoologist.

The expenditures of this Department of the School of Agriculture have been very small, as in the past. The funds allotted have sufficed to provide the supplies needed for routine work, but have not permitted any considerable increase in equipment. It has been needful to make occasional use of the Station microscope, refractometer, and other expensive apparatus, in order that the work of the Department might be satisfactorily carried on. A little has been done, however, in the way of labelling and re-arranging the illustrative material which has been slowly gathered from various sources.

The conditions under which the work in this Department has been performed, have been even more unsatisfactory than usual, owing to the transfer of my lecture room to a part of the old frame building somewhat remote from my supplies. This transfer seemed, however, the best solution of difficulties confronting another Department of the School. The increasing size of the classes in this course is, moreover, crowding our present laboratory space. Conflicts in the schedules of special and irregular students have made it needful to divide this year's Sophomore class into two sections; so, that, for this time, the desk room has been sufficient.

While the environment of the work of this Department has been far from encouraging, for some years past, the lecture-room, laboratory and related apartments allotted to my work in the new Agricultural Building now under construction, will, when they are properly equipped, handsomely provide for the conduct of the work on a considerably larger scale than at present. The plans which were, at your request, prepared by me for these new quarters, include a well-lighted lecture room, of size sufficient to seat fifty or more students. It is planned with reference to the installation of a modest equipment of cases for the exhibition of illustrative material, and of a suitably arranged lecture table with the usual conveniences, including a projection lantern. The main laboratory, to occupy the north corner of the second story, is intended to provide working space for a corresponding number of students, with thorough equipment for up-to-date instruction in agricultural analysis. Adjoining the laboratory are balance and store rooms. The room next to it on the west, though allotted for the present to serve as a class-room for another Department, has been provided with flues, water-gas-, and other piping, to fit it for later use as a laboratory for advanced students. Opening from the lecture-room, is a fair-sized preparing room, for the storage and preparation of demonstration material for the lectures in Agricultural Chemistry. This room also opens into the office allotted to the instructor in charge. A general store-room, a combustion-room and a polariscope-room are planned for the east end of the third story. It is arranged that the exhaust and blast engines, and also the water-still shall likewise be installed in this space.

It is hoped that sufficient electric power may be supplied to drive the blast apparatus, a small mill for preparing samples of plant materials, and electric centrifuges, in addition to that needed for illumination. Finally, space will be needed, either in the basement of the Agricultural Building or in that of the gallery connecting it with the Dairy Building, for the gas pump of the apparatus needed to generate gasoline gas for the laboratory fuel supply.

I have been very loyally assisted in my work by Messrs. McDowell and Pingree. Owing, however, to their relations to the Experiment Station, the proportion of their time that can properly be devoted to the work of instruction is insufficient to provide all the assistance needed. During the period of the Short Courses, the aid required is equivalent to more than the full time of one assistant; during the remainder of the year, it is possible to get through with aid corresponding to about one-fourth of the time of one assistant. Even now, from lack of assistance, much is left undone that should be done. It is earnestly recommended that provision be made to give the full time of an assistant to my Department when the new laboratories are occupied.

Very respectfully,

WILLIAM FREAR,
Professor of Agricultural Chemistry.

(c) BOTANY AND HORTICULTURE.

To the President:

Sir: In making a report of the Botanical Department, for the year 1905-6, I feel again that there is little occasion for any but a brief statement of the general conditions of the Department, its current work, and such ideas regarding educational methods and principles as experience under our conditions has impressed upon us.

The Department of Botany is not greatly changed, but it is sensibly improved. It has a better equipment of microscopes and accessible necessary material for instruction. It has had the largest classes in its history. It is for the first time fully upon the latest schedule of study, whereby the instruction begins with the second semester of the Freshman year.

It has been under increased disadvantage from narrow and contracted quarters, obliged to accommodate twenty students where there are places for only sixteen; to shift classes from room to room, so as to avoid conflict; to do without proper blackboard facilities, and, in some other ways, to be inconvenienced.

Considering these circumstances, the achievements have been at least fair to good. At this writing, with six weeks of the working year still unused, it is hardly possible to speak more exactly. From the teacher's standpoint, disappointment comes not so much from the lack of study or application of the student as from apparent failure to keep the "thread of the argument," to properly correlate the different parts of a subject and unify the whole: from inability or indisposition to do any more than "the law requires." When such is the case, the teacher's problem is to find the causes. They may be the lack of proper sequence and correlation of related subjects, unsuitable text-books or laboratory work, or the immaturity, if not the negligence, of the student himself. Commonly, several of these factors prevail, and are more or less difficult to correct. The problem is virtually the same in all departments, at least in kind, if not in degree; and this is hardly the place for its consideration. I have compactly stated my views on the subject and suggested some partial remedies in my report for 1902-3.

The lectures in Forestry have been given as heretofore. They are necessarily of a general character with but little specific illustration. When the Course in Forestry is put in practical operation they will need to be supplanted or amplified to meet the requirements of a full Course.

By your direction I took charge of the Sophomore General Biology during the first Semester of the year, and have continued to provide the botanical work in the Short Winter Course in Agriculture, and the Correspondence Course: likewise the several lectures called for by the special class of men who were being fitted for the San José Scale inspection work, together with such duties as were entrusted to me during your absence.

Respectfully submitted,

W. A. BUCKHOUT.

May 28, 1906.

(d) DAIRY HUSBANDRY.

To the President:

Sir: I have the honor to transmit the following report of the Department of Dairy Husbandry since I took charge of it December, 1905 (15).

Instruction has been given to thirty students in the winter Creamery Course. Those men who had previous experience in creamery work have all secured positions as butter makers. Others who completed the course and desired it, have secured positions as butter makers or helpers.

It is the practice of the Department not to recommend men to take charge of creameries, who have not had practical experience in addition to their college instruction and experience, but to send them out as helpers at first. The demand for butter makers and helpers has been much greater than the number of students available.

A brief course of lectures in Dairy Husbandry, with limited laboratory practice, was given to twenty students in the winter Course in Agriculture.

Instructors: Miss E. B. Meek, a graduate of The Pennsylvania State College, discontinued her work at the University of Chicago to give the instruction in dairy bacteriology to the Creamery Course class, and in general bacteriology to the regular students due for that work. The character of the instruction for the Creamery Course student was especially efficient considering the student's lack of preparation, the limited time available, and the improvised facilities for demonstration work.

Mr. E. F. Fortin, butter maker for the Harford (Pa.) Dairy Company, a former student in the Cornell Dairy School, was employed for part of the Creamery Course as assistant in practical creamery work. He brought to this duty a large experience and close touch with those difficulties the students will encounter in their commercial work in the creameries of the State.

The equipment was enlarged by the loan or purchase of a cream ripener, two pasteurizers, a cooler, three factory separators, eight different makes of hand separators; also by facilities which make it possible to give each student individual practice in the preparation and propagation of pure culture starters for cream ripening.

College Creamery. —The business and clerical work of the creamery operated in connection with this Department to secure a supply of material for laboratory practice, has been concentrated, under my direction, thus relieving the Business Office and the Secretary of the Experiment Station. A system of accounting, as nearly adapted to ordinary creamery practice as is practicable in college work, has been installed, the purpose being to furnish data needed for instructional purposes, yet requiring the minimum of labor.

The volume of business done during the year just closing has been sufficient to pay all expenses incident to the commercial phase of

the work. The price secured for the product has netted the farmers who patronize the creamery a better price than any other market available.

Other Work.—My own time, since the close of the winter course, has been largely occupied with the organization of the work, and getting acquainted with the existing dairy conditions in the State preparatory to enlarging the work of instruction, and increasing the usefulness of the Department to the dairy interests.

I have accepted invitations to speak at meetings of creamery patrons, farmers' institutes, county teachers' institutes, The State Dairy Union, State Department of Agriculture, and county Grange Meetings. These trips give an opportunity to learn something of conditions in many parts of the State.

I am gratified that I can report as a result of my brief acquaintance a marked interest in the work of the Department and manifest desire for such instruction and help as this Department should be prepared to give the dairy interests of Pennsylvania.

Respectfully submitted,

H. E. VAN NORMAN,
Professor of Dairy Husbandry.

II.—AGRICULTURAL EXPERIMENT STATION.

To the President:

Sir: I have the honor to submit the following report upon the work of the Agricultural Experiment Station for the year 1905-6.

PERSONNEL.

With the opening of the year, the staff of the Station was enlarged by the appointment of Assistant Professor Thomas I. Mairs as head of the Station work in Animal Industry. During previous years, Professor Mairs has voluntarily assisted in the work of the Station, as mentioned in previous reports, so that his appointment was rather a recognition of work completed and in progress than an actual addition to the working force of the Station.

While there have been somewhat fewer changes among the assistants of the Station than occurred last year, they have still been more numerous than is consistent with the development of a strong and experienced force.

Mr. N. G. Miller, B. S., terminated his engagement as assistant in Agriculture on June 16, just before the close of the last fiscal year and after my previous report had been submitted. The vacancy thus created was filled by the appointment of Mr. F. W. Christensen, who during the previous year served as assistant in Animal Nutrition under appointment from the U. S. Department of Agriculture, as assistant in Agronomy and Animal Industry.

Mr. A. W. Clark, B. S., assistant chemist, resigned on July 18.

Miss Eva Jones, stenographer, resigned on August 12, the vacancy being filled by the appointment of Miss Alice R. Jones.

Miss E. F. Jones, stenographer, resigned on September 1, the vacancy being filled by the appointment of Miss M. Isabel Innes.

Mr. Percy W. Flint, B. S., was appointed assistant chemist, September 1, to fill the vacancy created by the resignation of Mr. A. W. Clark already noted.

Mr. R. E. Stallings, B. S., assistant in Animal Nutrition, resigned on October 1, the vacancy thus created being filled by the appointment of Mr. J. H. Parkins, B. S., on the same date.

Mr. W. A. Smith, B. S., assistant chemist, resigned on November 17, the vacancy thus created being filled on January 1 by the appointment of Mr. J. W. White, B. S.

Mr. J. H. Parkins, whose appointment is noted above, resigned on May 10. The vacancy thus created has not yet been filled.

In addition to the above resignations and appointments, some temporary changes have been found necessary during the year. In November, Mr. N. C. Hamner, assistant chemist, became seriously ill and was given an extended leave of absence to complete his recovery, he not returning to duty until March 23. A portion of Mr. Hamner's time had been assigned to the investigations in Animal Nutrition, the corresponding portion of his salary being paid by the U. S. Department of Agriculture. In order to prevent interruption of this work, Mr. F. W. Christensen was transferred, January 1, to temporarily fill Mr. Hamner's place, while the vacancy occasioned by this transfer was filled by the temporary appointment of Mr. E. H. Hess, B. S., a graduate of the Class of 1900, and later by the temporary appointment of Mr. F. S. Putney, B. S., the latter appointment having been continued to the present time.

WORK OF THE YEAR.

Agricultural Chemistry.—Except in one particular the work of this Division has been much the same as in previous years. The exception consists in the co-operative soil tests with fertilizers which have been inaugurated on the plan described in the last Annual Report of the Station. This comparatively simple plan, devised by the Chemist of the Station, is intended to enable the individual farmer, at comparatively small expense, to learn something as to the main fertilizer requirements of his soil. Although this plan was first published in the spring of 1905, it met with little response. In the spring of 1906 attention was again called to the matter, early in the season, and the Station offered to supply the necessary fertilizers, weighed out and ready for application, to the first 100 applicants, of whom, however, not more than 10 should be residents of the same county. In response to this offer over 250 applications for the fertilizers were received. The sets were allotted to residents of 38 different counties of this State, and a number of other farmers who were not early enough in applying or who desired to experiment upon a larger scale arranged to make the co-operative tests with fertilizers purchased for them by the Station at their cost. It is believed that the experiments thus inaugurated, besides proving of much benefit to the experimenters and their neighbors, may be of considerable value as a preliminary study of the soils of the State and, it is hoped, may lead not only to more extensive investigations in the field, but more fundamental and thorough investigations in the laboratory and plant house.

The investigations upon the culture and curing of tobacco, which have been carried on by this Division for a number of years, have been continued and somewhat extended with the aid of the State appropriation made by the last Legislature.

Experiments upon the growth of Sumatra wrapper leaf under shade have been continued at two localities in Lancaster county and a factory test of the commercial quality of the crop of 1904 has been made. While not conclusive, the results of the three years' work are very decidedly encouraging as regards the growth of this type of tobacco on the lighter soils of the county. Incidental to these experiments, a trial is being made of the Russian Sand Vetch as a means of renovating the light soil which had been used continuously

for tobacco culture and thereby brought into bad mechanical condition. Some laboratory studies of the same soil are also under way.

A beginning has been made in a study of the influence of seed selection upon the type and form of Sumatra leaf obtained, but the work has not been continued long enough to permit of any definite report.

At the earnest request of the Lancaster County Tobacco Growers' Association, a study of the practical prevention of pole burn in tobacco has been begun, the method of experiment being the use of artificial heat and ventilation during the critical periods of curing. The method is one requiring considerable skill and experience, and it is not surprising that the first attempt was not altogether successful. It is believed, however, that the method has sufficient promise to warrant further trial under, if possible, closer personal supervision by a trained observer.

As in previous years, a large number of samples of milk have been analyzed by the Division in connection with tests of dairy cattle conducted under the supervision of the various breeders' associations. In addition to this, herd tests at the homes of owners have been conducted at several different times during the year, although it has been impossible to provide sufficient forse to meet the numerous and increasing demands in this direction.

The routine analytical work of the Division has, as in earlier years, consumed the larger share of the time and energy of the Chemist and his assistants. This routine work includes analyses of official fertilizer samples collected by the State Department of Agriculture, together with other miscellaneous work received from the Department, and the analyses made in connection with experiments carried out by other Divisions of the Station, in particular the Division of Animal Nutrition. The analysis of samples of commercial feeding stuffs collected by the State Department of Agriculture has been transferred to its own laboratory at Harrisburg, but, on the other hand, the demands upon the Division of Agricultural Chemistry have been somewhat increased by the decision of the Trustees to undertake analyses for the millers of the State of goods produced by them and required under State law to bear a guarantee of composition.

The meteorological observations have continued in charge of this Division of the Station, and the Chemist has continued to serve, as in previous years, as Chairman of the Committee on Food Standards commissioned by the U. S. Secretary of Agriculture to collaborate with him in fixing standards of purity for foods.

Agriculture and Poultry.—A considerable part of the work of this Division, as in previous years, has been in continuation of experiments that were initiated many years ago. The so called "general fertilizer experiments" have been conducted for twenty-four years and cover six complete rotations. The results of these experiments are each year becoming more valuable. They have been continued for a longer period than any similar tests in this country, and their average results should therefore largely eliminate accidental variations. In addition to the direct results of the experiments, the plats themselves, with a known history of nearly a

quarter of a century, offer most valuable material for soil study, whenever the means of the Station permit this to be taken up.

The variety tests of farm crops continue to show a marked difference in the productiveness of the various varieties, and indicate that the yield of farm crops in the State may be very much increased by greater care in the selection of seed.

During the year, tests of soiling crops which were begun two years ago were continued in co-operation with the Division of Animal Nutrition.

The most important new work of the Division has been the initiation of experimental work upon poultry, which has been assigned to this Division partly as a matter of convenience but largely on account of Professor Watson's recognized position as an authority on this subject. Previous to this year, our equipment as regards poultry was exceedingly meagre. With the aid of the special State appropriation made by the last Legislature this state of affairs has been materially bettered. There have been erected a one-story brick incubator building, 19 by 25 feet, two permanent poultry houses, 12 by 20 feet, and six brooder and colony houses. Additional fowls have also been purchased, and at the present time the Station is maintaining flocks representing four classes of fowls, three of which are being used for experimental purposes, namely, the American, the Mediterranean and the Asiatic classes. The increase in equipment has not been available long enough to permit the attainment of any experimental results, but it is expected that interesting and valuable work will be done during the coming year.

Animal Industry.—As noted above, the feeding of soiling crops in continuation of experiments conducted for the past three years has been in charge of this Division in co-operation with the Division of Agriculture. Certain crops previously experimented with have been discarded, and it is believed that a fairly satisfactory rotation of soiling crops for this section of the State has been secured.

The preliminary observations on the protein supply of the dairy herd, which were partially reported a year ago, were continued to January 1, 1906, or a full calendar year. While the results do not warrant any radical conclusion, they indicate that the supply of protein in excess of that required for maintenance plus that contained in the milk is of less importance than was formerly believed, and may easily be too expensive for the best economical results.

During the winter, a feeding experiment was made to test the value of "alfalfa meal," which has been recommended as a substitute for wheat bran. At the prices asked for the former, it is more expensive than bran, and in this experiment showed no advantage over the latter. Alfalfa is, of course, an exceedingly valuable feed, especially for dairy cows, but the farmers of Pennsylvania should raise it themselves and get the advantage of its fertilizing effect upon the soil, rather than purchase it in the form of alfalfa meal at relatively high prices. With a plentiful supply of home grown alfalfa, clover, or other leguminous crops, a suitable ration can easily be made up from the more common farm grains or by-products which are generally cheaper relatively than bran. This is especially true in view of our own experimental results and

those of others which seem to show that the proteid demands of dairy cattle have been over estimated.

The experiments upon the value of shelter for fattening steers have been continued, with results corroborating those of former years, namely, that temperature does not materially affect the gain, but that dry quarters are of very great importance.

The invention of what seems to be a practicable milking machine is a matter of much importance to the owners of large herds. Arrangements have accordingly been made with D. H. Burrell & Co., Little Falls, N. Y., to place one of their milking machines at the Station for test and it is expected that it will be installed within a short time.

I regret to state that tuberculosis has again appeared in the Station herd, which has been free from it since 1892. A test, under the direction of Dr. Leonard Pearson, State Veterinarian, during the month of March resulted in the condemnation and slaughter of 15 animals. As the herd was free from tuberculosis when last tested, and as no animals had been bought except a bull, which was purchased after a tuberculin test by a competent veterinarian, and which came from a farm said never to have had a case of tuberculosis, the appearance of the disease here was quite unexpected. During the summer of 1902 some of the heifers and one cow were taken to a pasture in the mountains. Here they ran for some months with about two hundred head of other cattle. It is possible that the disease was contracted from the strange cattle in this pasture and then transmitted to others in the Station herd. The barns have been thoroughly disinfected under the direction of the Live Stock Sanitary Board and it is thought that no further development of the disease will take place.

Animal Nutrition.—The Division of Animal Nutrition has continued to enjoy the co-operation of the Bureau of Animal Industry of the U. S. Department of Agriculture. During the year the experiment outlined in my previous report upon the influence of age and individuality upon the rate of gain has been continued. The past season's work has but recently been completed, and it has not yet been possible to finish the computation of the results; consequently, definite report upon the progress of the experiments must be deferred for the present. A bulletin upon the available energy of clover hay, supplementary to the one published as Bulletin No. 74 of the Bureau of Animal Industry, is nearly ready for publication. Some minor improvements in the apparatus have also been made during the year.

Horticulture.—The available funds of the Station have not permitted of any extension of the strictly horticultural work beyond the testing of varieties which has been continued for a number of years past. Several other lines of work not strictly horticultural have, however, been taken up.

The popular interest excited by the advertisement of the so-called "nitro cultures," i. e., cultures of the bacteria which enable leguminous crops to assimilate the free nitrogen of the air, led to the inauguration of a series of tests of the cultures as offered commercially to the trade. The trials included pot experiments in the green house in sterilized sand and field cultures. Since neither method of trial showed any particular advantage arising from the

use of the commercial cultures, we feel justified in warning farmers against expending any considerable amount of money in their purchase. At the same time, however, it should be noted that this conclusion does not in any way modify the fact of the importance of these bacteria in the soil, nor does it show that artificial inoculation of the soil is impracticable, but simply that the particular form of culture which has been offered is not effective.

Experiments have been inaugurated in co-operation with celery growers in the vicinity of Wellsboro, Tioga County, with reference to the control of the celery rust which has caused much loss in that region. Similar co-operative experiments on the control of the black rot of the grape in Erie County in 1903 have proved eminently satisfactory to the growers. A recent visit to that section by the Horticulturist showed a general use of spraying, in accordance with the Station's recommendations. A representative of the Bureau of Plant Industry of the U. S. Department of Agriculture is now planning some investigations in that region on the life history of the black rot fungus, and the Station is keeping in touch with the work although not actually co-operating to any considerable extent.

At farmers' institutes and other like organizations during the winter, farmers of the State were invited to send specimens of their seeds to the Station for investigation as to vitality and purity. Some 46 samples have been received, their examination being assigned to the Horticulturist. In the same line, samples of seed corn have recently been collected from various parts of the State by the Agriculturist, and are now being tested by the Horticulturist as to germinative power.

The Horticulturist of the Station has assisted during the months of December and January at farmers' institutes in the State, and during the month of August acted as Nursery Inspector for the State Department of Agriculture.

Secretary's Office.—The work of the Secretary's Office includes the care of the Station accounts, the general charge of the correspondence, the mailing of publications and the care of the library and reading room.

The correspondence of the Station has shown a decided increase during the year, and notwithstanding the entire change in the stenographic force, the work has been carried on in a very satisfactory manner.

The publications of the Station have included the Annual Report for the year 1904-5, which is now in press, and six bulletins as follows:

No. 72. Experiments in Growing Sumatra Tobacco under Shelter Tent, 1903.

No. 73. Distillers' Dried Grains vs. Cottonseed Meal as a Source of Protein.

No. 74. Methods of Steer Feeding.

No. 75. Forage and Soiling Experiments, 1904.

No. 76. Variety Tests of Wheat, Oats and Potatoes.

No. 77. Small Fruits in 1905.

A number of press bulletins have also been issued. As noted in my last report, the quota of Annual Reports assigned to the Station has been reduced from 10,000 to 3,600 copies, so that after supplying the newspapers of the State and kindred institutions in other

states, both of which must be done under the provisions of the Hatch Act, practically no reports are available for distribution to individuals. The mailing list of the Station has increased by the addition of more than one thousand new names, the total being over 17,000. During the latter part of the year the mailing room was transferred from the cellar of the Station building to the old dairy building. With a few changes this building was put in fair condition to accommodate this work and render the care of the mailing much more easy.

The library of the Station has increased during the year chiefly by the accumulation of periodicals and of the bulletins and reports of other Stations. Our general policy has been to expend the larger portion of the fund assigned to the library in the purchase of technical journals of standard character, so that the Station now possesses files of the more important agricultural, chemical, botanical and physiological journals of this and other countries, which are of great and increasing value in research. Additional shelf room is seriously needed for the proper accommodation of the library.

As noted in my last report, the Legislature of 1905 made an appropriation of $2,500 for the erection of an implement shed and poultry houses, and one of $5,000 per year for the general maintenance of the Station. With the former appropriation an implement shed 45 by 80 feet has been erected and also the incubator and poultry houses mentioned in connection with the poultry work. Of the appropriation for maintenance, $1,500 was assigned to investigations upon the culture and curing of tobacco, as noted in connection with the work of the Division of Agricultural Chemistry. Pending the reorganization of the entire agricultural work of the College, no further appropriations from this fund have been made with the exception of a small amount for experiments with poultry. Accordingly, there has been no very marked extension of the Station work during the year past, while a correspondingly large portion of this fund will be available for the coming year.

Respectfully submitted,

HENRY PRENTISS ARMSBY,
Director.

III.—THE CARNEGIE LIBRARY.

To the President:

Sir: It may be of interest, in presenting the Report of the Library for the year 1905-6, to compare the present status with that of the first published report. The Librarian writing in 1879, says: "Upon investigation I found that the material on hand had not been arranged according to any special order. I then proceeded to overhaul and rearrange, adopting what is called the topical arrangement. Thus far my classification, which I think will answer our needs for the present, is as follows: Physics, Chemistry, Agriculture, Geology, Government Documents, Botany and Zoology, general reference, and miscellaneous." Previous to 1879, the library was not regularly open, and the Librarian reports a beginning of one hour per day for the first year, with an average of three visits a day. The collection numbered about two thousand volumes, with no catalogue, located in a room in the main building, 24x46, to which a small reading room was added in 1879.

Now the library is splendidly housed in a modern building, open for use fourteen hours daily, with reading room open six hours on Sunday. The collection numbers nearly twenty-four thousand volumes (exclusive of pamphlets), classified under a slightly modified decimal system, thoroughly catalogued, and consulted by scores of readers every day.

The work of the past year shows a gratifying advance. The use of the library both recorded and unrecorded has increased. The wisdom of keeping the building open during the noon and early evening hours has been abundantly demonstrated, as a considerable number of students find portions of these hours available for general and specific reading. The regard for the building, and respect for the uses of the library, have been all that could be desired. But the instances in which a book is reported missing or a periodical thoughtlessly cut (although comparatively rare) are yet such as to make one sigh for a nearer approach to the millenium.

The magazine list has been increased and strengthened during the year. Many of these are tools of the special student, while others stimulate general reading and convey current information. The latter, too, with the various indexes supplied, render the purchase of many current and ephemeral books unnecessary, thus permitting the book fund to be expended for works of permanent and scientific interest. Dailies in both German and French have been subscribed for, the Modern Language Departments recommending them as especially helpful to their work.

The total number of periodicals received or available at the library is as follows:

Main library by purchase,	106
Main library by gift,	99
Taken by departments,	113
Natural History Club, gift,	10
Mathematical Club (deposited in seminary room),	9
Total,	337

In many cases, the bound volumes of these department periodicals become part of the main library; while in others, an arrangement has been made whereby any number or volume required may be loaned to the main library for specified times. Thus the entire resources of the institution are available at the main library, although serving special interests in department collections. By a system of exchange, the periodical list could be greatly increased. The library is ready to add its quota to a college publication which should serve as an adequate medium of exchange with other colleges, with scientific societies, and other organizations the world over.

The Library has been open fourteen hours daily, with the reading room open six hours on Sundays. The long hours are abundantly justified, notwithstanding they require two seven hour shifts in every day to serve the desk. Moreover the catalogue is coming to demand one person's time and there is a considerable amount of filing and indexing in the basement, replacing books and keeping stacks in order, repairing and relabeling, compiling reference and other lists, only a part of which can be done in connection with the desk service.

Special work prosecuted during the year may be mentioned. The Agricultural Cards, which have been accumulating for some years, have been set up. These index the publications of the Department at Washington, and the bulletins of the several Agricultural Experiment Stations. A separate index of what we have has been compiled, and a systematic effort has been and is being made to complete our files. A list of duplicates of every sort is also under way, and it is hoped to utilize this for exchanges in connection with a list of wants. A card index of Theses by Courses and filed alphabetically by subjects has proved a helpful tool. Anyone interested may, without loss of time, run over the list of subjects previously treated, and determine at a glance by whom submitted and the date. A beginning has been made toward a collection of industrial catalogues and bulletins. An adequate filing case should be provided that this material may be readily accessible and the collection increased. The principal auction catalogues, book catalogues, circulars of rare and unusual publications, books called for, books and periodicals needed, etc., have been systematically filed. These are frequently consulted.

The pamphlet material has been reviewed and culled, and the filing made more effective by additional cases. An estimate of the number of volumes for binding has also been prepared, and it is earnestly recommended that a sufficient sum to cover this binding item be available. Special attention has been given during the year to a collection of State College publications, and several rare items have been found. In some cases the files have been made complete. A bibliography of alumnal publications has been under-

taken, and copies of writings acquired. With the hearty responses which appeals for aid in this work have met, it should be possible to set apart an alcove for a complete collection of college (official), alumnal and student publications. This should be extended to include prize orations and commencement parts. The adoption of a rule by which no prize is awarded or degree granted until a copy of the production is filed at the Library would facilitate the task of securing future numbers.

Arrangements have been effected with the principal libraries of the east for the loan of books, and the Library Committee has authorized the payment of half the carriage of such loans when approved by the head of any department. The Library has had, too, a growing correspondence with alumni and others seeking information concerning books and authorities, and in a few cases persons have come from other parts of the State to work with our collection. To the full extent of our resources, we gladly comply with requests from any part of the State for bibliographic aid; and to this end it should be the special concern of the Library Committee to provide a really thorough reference collection, historical and present.

By way of statistical review, I take the following from the monthly reports of Accession and Catalogue, and from the Desk Report:

Number of volumes in the Library, April 30, 1906, ...	23,065
Accessions for the year, 1905-6, ...	1,402

Volumes Catalogued During the Year.

Main library, ...	1,412
Biology, ...	37
Chemistry, ...	27
Mechanical engineering, ...	16
Mining engineering, ...	7
Physics, ...	5
Cards purchased, ...	2,162
Cards made, ...	3,330

	1905-6.	1904-5.
Readers' Cards Issued:		
C, ...	258	144
D, ...	44	20
Total, ...	302	164
Circulation:		
C, ...	866	358
R C, ...	346	212
D, ...	714	129
Total, ...	1,926	699

The preceding figures have little significance as showing the real use of the collection. No record is kept of the use of books in the building. The Library is primarily for reference, and until last year no books at all were withdrawn. The increase, however, in circula-

tion is marked, as well as in the number of readers' cards issued. But so slight a percentage of the books circulate, the accessions are so few in popular works, that our circulation figures will probably not be large under present conditions. The Library being open, too, fourteen hours of every working day furnishes ample time and opportunity, under the most comfortable conditions, for reading and study.

The year has been noteworthy by way of gifts. General Charles Miller donated seventy-five volumes, and in addition authorized the Librarian to subscribe for the Alleyne Ireland Report on Colonial Administration in the Far East, twelve volumes, a costly and valuable set. From General James A. Beaver came forty-five volumes and nine pamphlets; from the Hon. Ellis F. Orvis, thirty-two volumes, and from the Rev. James O. Denniston, twenty volumes. In addition to members of the faculty, due acknowledgment of whose gifts have been made, the following alumni and students have contributed volumes or pamphlets during the year: John Hamilton, W. A. Buckhout, G. C. Butz, E. P. Humes, E. R. Chambers, Ellis F. Orvis, J. H. Shields, Wm. F. White, Gilbert A. Beaver, Thomas Beaver, Nelson Lloyd, W. A. Affelder, F. A. R. Hoeffeditz, I. P. Thompson, W. Y. Heaton, Frank C. Foote, H. H. Atherton and J. B. Wyckoff. No more pressing or vital opportunity confronts the alumni of The Pennsylvania State College to-day than the one of providing for the Library. This is a most logical direction of alumnal effort, too, since all departments, all students, present and future, are affected.

A List of Donors Follows.

Donor.	Books.	Pamphlets.	Periodicals.	Maps.
Alabama Geological Survey,		1		
Alumni Association, The Pa. State College,		1		
American Breeders' Association,		1		
American Iron and Steel Association,		1		
Anthracite Association News,		1		
Astor, John Jacob,	1			
Atherton, George W.,	14	71	43	
Atherton, H. H., and Wyckoff, J. B.,	1			
Auburn Seminary,		5		
Auction Catalogues:				
Anderson Auction Company,		30		
Henkels, Stan. V.,		15		
C. F. Libbie and Company,		2		
Merwin-Clayton Sales Company,		48		
M. Thomas and Sons,		1		
Baylor University,		3		
Beaver, Gilbert A.,	3			
Beaver, James A.,	45			
Beaver, Thomas,	3			
Blackman, Wm. F.,		1		
"Book Fund," London,	1			
Boston Museum of Fine Arts,	2	16		
Boston Transit Commission,	1			
Braumuller, William,	1			
Brigham Young College,		1		
Brill, J. G., and Company,	1			
Brooklyn Institute of Arts and Sciences,	1	6		
Brown University,		1		
Buckhout, W. A.,	18		25	
Bucknell University,		5		
Butz, George C.,		2		
Canada, Department of Marine and Fisheries,		10		
Canada, Patent Office,		3		
Caproni, P. P., and Brother,	1			

A List of Donors—Continued.

Donor.	Books.	Pamphlets.	Periodicals.	Maps.
Carnegie, Andrew,	1			
Carnegie Institution,	24			
Carnegie Library, Bradford,		2		
Carnegie Technical Schools,		1		
Cassella Color Company,	1	93		
Chambers, E. R.,	2			
Chautauqua Quarterly,		2		
Cincinnati Society of Natural History,		4		
Clarkson School of Technology,		9		
Clark University Library,		1		
Cleveland Public Library,		1		
Colorado Iron Works,		2		
Consumers' League of the City of New York,		1		
Cross, William,		3		
Dartmouth College,	1			
Denniston, J. O.,	20	52		
Dixon Crucible Company,		12		
DuBois, W. E. B.,		6		
Espenshade, A. Howry,	1			
Executive Committee, 250th Anniversary of the Settlement of the Jews in the U. S.,	1			
Ferrier, Francis,		1		
Field Columbian Museum,	1	5		
Florida Department of Agriculture,		2		
Foote, Frank C.,	2			
Franklin and Marshall College,		1		
Free Library, Philadelphia,		3		
Friends' Peace Conference,		2		
Frizzell, J. H.,		2		
Fuller, George A.,	1			
Fulton Iron Works,		1		
Georgetown University,		1		
Georgia, Department of Agriculture,		1		
Gill, Benjamin,			3	
Great Britain, Patent Office,		7		
Gridley, Albert L.,		2		
Hamilton, John,		4		
Hartford Theological Seminary,		1		
Heaton, W. Y., for Class of 1906,	1			
Hobart College,		3		
Hoepli, Ulrico,		1		
Hoffeditz, F. A. R.,		1		
Hughes, J. H.,		4		
Hyde, James H.,	1			
Illinois State Laboratory of Natural History,		2		
Imperial German Consul-General, New York,	1			
India Government Press,		1		
International Bureau of Exchange,		1		
Inter-State Commerce Commission,	2			
Iowa Academy of Sciences,	1			
Iowa Geological Survey,	1			
Jenks, W. J.,		1		
John Crerar Library,		1		
Johnston, F. H.,		1		
John Hopkins University,		1		
Kansas State Agricultural College,		1		
Koniglich Preussichen Akademie der Wissenschaften,	1			
Lacey, John F.,		1		
Lake Forest College,		1		
Leary Stuart and Company,	3			
Lee, Gerald Stanley,		8		
Lee and Shepard,	1	1		
Leete, J. H., Secretary's Office,	4	79		
Leland Stanford, Jr., University,		2		
Library, Cornell University,		1		
Library, Providence Public,		2		
Louisiana, Geological Survey,		2		
Mairs, T. I.,			6	
Manila, Department of the Interior,		2		
Marburg Institute for Research against Infectious Diseases,		1		
Marks, Wm. D.,	1	4		
Maryland Agricultural College,		2		
Massachusetts Institute of Technology,		31		
Massachusetts State Library,	4			
Meek Brothers,	1			
Merchants' Association, New York,		2		
Metropolitan Museum of Fine Arts,		5		
Michigan Academy of Sciences,		3		
Michigan State Agricultural College,		1		
Miller, Charles,	75			
Miller, Kelly,		1		
Mohonk Lake Conference,		1		
Montana Agricultural College,		1		

A List of Donors—Continued.

Donor.	Books.	Pamphlets.	Periodicals.	Maps.
Mowry, Don Ensminger,	.....	1	.....	.....
Munn and Company,	.....	1	.....	.....
Myers, William F.,	1	1	.....	.....
National Academy of Sciences,	.....	3	.....	.....
National Dairy Association of New Zealand,	.....	1	.....	.....
National Irrigation Congress,	2	.....	.....	.....
National Manufacturers' Association,	.....	1	.....	.....
Newcomb, H. T.,	.....	1	.....	.....
New England Moral Reform Society,	.....	5	.....	.....
New Jersey State Board of Agriculture,	1	.....	.....	.....
New Jersey State Geologist,	1	.....	.....	.....
New York State Education Department,	1	.....	.....	.....
New York State Library,	.....	10	.....	.....
New Zealand Public Service,	.....	1	.....	.....
North Carolina Department of Agriculture,	.....	12	.....	.....
Northwestern University,	.....	4	.....	.....
Orvis, Ellis F.,	32	.....	.....	.....
Osmond, I. T.,	5	.....	.....	.....
Pattee, F. L.,	8	52	.....	.....
Patton, John,	1	.....	.....	.....
Peet, Stephen D.,	.....	1	.....	.....
Stockwell, Thomas B.,	1	.....	.....	.....
Sturtevant, B. F.,	1	.....	.....	.....
Superintendent of Parish Schools, Philadelphia,	.....	5	.....	.....
Surface, H. A.,	3	32	.....	.....
Swarthmore College,	.....	1	.....	.....
Taber, Sydney Richard,	.....	1	.....	.....
Texas Commissioner of Agriculture,	2	.....	.....	.....
Thompson, Irvin P.,	1	.....	.....	.....
Trinity College,	.....	3	.....	.....
University of Arizona,	.....	1	.....	.....
University of Chicago,	.....	.....	240	.....
University Club, New York,	1	.....	.....	.....
University, Colorado,	.....	3	.....	.....
University, Illinois,	.....	2	.....	.....
University, Maine,	.....	1	.....	.....
University, Michigan,	.....	1	.....	.....
University, Minnesota,	.....	4	.....	.....
University, Missouri,	.....	5	.....	.....
University, Montana,	.....	7	.....	.....
University, North Carolina,	.....	1	.....	.....
University, Dakota,	.....	1	.....	.....
University, Oregon,	.....	1	.....	.....
University, Vermont,	.....	1	.....	.....
University, Wisconsin,	.....	4	.....	.....
University, Wyoming,	.....	1	.....	.....
Union League, Philadelphia,	.....	1	.....	.....
United States, Census Department,	4	33	.....	.....
United States Civil Service Commission,	1	.....	.....	.....
United States, Department of Agriculture,	11	141	.....	.....
United States, Forest Service,	2	76	.....	.....
United States, Department of Commerce and Labor,	8	39	.....	.....
United States, Department of the Interior,	2	4	.....	.....
United States, Geological Survey,	1	24	.....	126
United States, Library of Congress,	.....	9	.....	.....
United States, Naval Observatory,	2	1	.....	.....
Navy Department,	.....	2	.....	.....
Patent Office,	2	86	.....	.....
State Department,	1	1	.....	.....
United States, Superintendent of Documents,	410	.....	.....	.....
Superintendent of Documents,	357	271	.....	27
Treasury Department,	1	3	.....	.....
War Department,	1	4	.....	.....
Vanderbilt University,	.....	5	.....	.....
Vassar College,	.....	1	.....	.....
Veterinarians' Association, Starkenberg, Germany,	.....	1	.....	.....
D'Enrique Gadeo Y. Villardebo,	.....	1	.....	.....
Wack, Henry Wellington,	1	.....	.....	.....
Warren, State Hospital,	.....	1	.....	.....
Watson, George C.,	12	21	71	.....
Washington and Jefferson College,	.....	1	.....	.....
Washington University,	.....	3	.....	.....
Welcome Chemical Research Laboratories,	.....	54	.....	.....
White, Wm. F.,	.....	2	.....	.....
Willard, J. M.,	.....	3	.....	.....
Willard, Jennie M.,	7	.....	.....	.....
Y. M. C. A., State College,	2	.....	.....	.....
Young Women's Christian Association of Pennsylvania and Maryland,	.....	1	.....	.....
Total (1905-6),	1,379	3,065	542	154
Total (1904-5),	514	1,190	532	.....

The following papers and journals have been donated to the Library during the year:

Advocate of Peace.
Agricultural News.
American Economist.
American Industrialist.
Bath Record.
Bellefonte Keystone Gazette.
Bellefonte Republican.
Bellefonte Watchman.
Bird Lore.
Bird Magazine.
Birds and Nature.
Book Buyer.
Boston Bulletin of Bibliography.
Brains.
Brockwayville Record.
Brookville Republican.
Bryn Mawr Record.
Bulletins:
Bosler Memorial Library.
Pratt Institute.
Brooklyn Public Library.
New York Free Public Library.
Osterhaut Public Library.
Otis and Peck.
Providence Public Library.
Salem Public Library.
San Francisco Public Library.
Springfield Free Public Library.
Clearfield Republican.
Collegeville Independent.
Current Literature.
Case and Comment.
Catalogue of U. S. Documents.
Canadian Entomologist.
Centre Hall Reporter.
Churchman.
Clearfield Public Spirit.
Daily New Era, Lancaster.
Darby Progress.
Democratic Vindicator.
Elk County Gazette.
Engineering World.
Evening Telegraph.
Far Eastern Review.
Farm and Fireside.
Farmers' Friend.
Farm Progress.
Field and Stream.
Forest Leaves.
Forest Republican.
Fruit Grower.
Gleanings in Bee Culture.
Greencastle Press.
Harrisburg Churchman.
Illuminating Engineer.
Indiana Weekly Messenger.
Iron Trade Review.
Jermyn Press.
Journal of Zoophily.
Laceyville Messenger.
Lansdale Republican.
Latrobe Bulletin.
Lawrenceville Herald.
Library Work.
Media Ledger.
Meyersdale Commercial.
Mifflinburg Telegraph.
Milk Reporter.
Mt. Jewett Herald.
Mt. Joy Herald.
National Farmer and Stock Grower.
National Stockman and Farmer.
New Hampshire Farmer.
Oil City Derrick.
Our Dumb Animals.
Outdoor Life.
Pennsylvania Argus.
Pennsylvania Farmer.
Pennsylvania Grange News.
Pennsylvania Hawkeye.
Pennsylvania School Journal.
Practical Farmer.
Psyche.
Punxsutawney Spirit.
Quakertown Times.
Recreation.
Republic (St. Louis).
Scranton Tribune.
Sunset.
Technical World.
Technology Review.
United Presbyterian.
Volksfreund und Beobachter.
Watson's Magazine.
Wayne Independent.
Wilkes-Barre Leader.
Williamsport Sun.
Windber Era.
Woman's Home Companion.

Total 1905-6, ... 99
Total 1904-5, ... 53

Additional equipment should be provided as quickly as possible. The map and chart room and the vault need cases. Additional shelving for newspaper files must be provided. The engineering alcove does not hold the books brought up from the engineering building in addition to those already there. If the seminar rooms were provided with cases, special collections could be removed thence, and an additional stimulus given to their use.

Our greatest need is an adequate fund for the purchase of books. Second only in importance to the men who head the Departments is the collection of books which are their tools. Starve the Library, therefore, and you lessen the efficiency of every line of work. Not alone the number of books purchased but more the quality tells. Here a college library has a peculiar advantage, in that its purchases may have the aid and advice of a large body of experts. This insures the best books in the various sciences and arts, while the work of the Librarian and Library Committee will be to check the over-zealous, to look after the interests of weak and neglected departments, and to secure to the Library a systematic and organic growth.

The acquirement of a special collection, the founding of a fund for specific subjects would do much to add real scholarship to our interests. The purchase of the Anthony Library, says ex-President White, absolutely established the classics at Cornell. The Dante, Spiniza, and White Historical Collections make the Cornell Library a Mecca for scholarship in these fields. The John Carter Brown, the John Crerar Library, the Avery, the Bancroft, the Kenerson, and many other collections, at once give distinction and opportunity to the several possessors.

The need is no less pressing here. We should have, for example, an adequate fund for a strong chemical library, and it might most fittingly bear the honored name, The Evan Pugh Memorial Fund of Chemistry. A Morrill Fund of History or of Literature, a Josiah Jackson Fund of Mathematics or of Engineering, are others that ought to inspire alumni and friends of the College to corresponding deeds. Such historical, personal gifts have subtle but far reaching influences upon the life of a college. They outlast buildings because they are continually vitalizing young human lives. It is to be confidently hoped that the near future will bring us some friend or friends whose beneficence will take direction from the opportunity, the pressing needs before us as a Library. Ten thousand dollars annually is the minimum amount that the Library should have to meet the bare needs of administration, accessions, binding, periodicals, etc.

I desire to call your attention urgently to the wisdom and necessity of filling certain of our files of periodicals and of obtaining others complete. There is an unusual demand for many of these sets, owing to the rapid multiplication of libraries, and to the thorough system of indexing now provided from several sources. The difficulty of securing and the cost thereof are rapidly increasing. The same is true of scientific and technical journals. These are a library's most valuable asset, and bring large returns in use because they embody both the latest results of the several sciences and furnish the raw materials for the history of any branch of learning. A definite sum at the disposal of the Librarian would

enable him to take advantage of special opportunities from time to time, opportunities which must usually be acted upon quickly if they are to be realized.

I need not speak in detail of the work of the staff, results show for themselves. Miss H. M. Bradley (after a year of study at Cornell University) returns to the Library. Her years of service render it unnecessary to write of her work and worth. Miss Anna MacDonald has given a greater part of her time to the catalogue, and this is gradually being worked over into an adequate dictionary catalogue. Miss S. K. Becker, who so efficiently served as substitute last year, has been added to the staff, the long hours involved in the schedule, the increase in reference work, and additional supervision in the new building requiring more help throughout the period when College is in session.

Thanking you, sir, for continued counsel and personal inspiration, the Library Committee for uniform courtesy and helpfulness and the staff for faithful co-operation in the Library's best interests, this report is respectfully submitted.

ERWIN W. RUNKLE,
Librarian.

May 28, 1906.

Supplementary Report.

I desire to present the following as a minimum list of expenditures required to meet the actual, pressing demands upon the Library:

Continuations,	$100 00
Supplies, cards, labels, postage,	100 00
Periodical list,	400 00
Binding,	400 00
Librarian's fund, filling sets, purchases from auction and second-hand catalogues,	1,000 00
Book fund (seven schools),	3,500 00
Administration, janitor, etc.,	4,000 00
Additional equipment and contingency,	500 00

ERWIN W. RUNKLE,
Librarian.

May 28, 1906.

IV.—CHEMISTRY.

To the President:

Sir: I have the honor to report that the usual work has been accomplished in the usual way by this Department during the year just now coming to a close, without incident of any kind which calls for especial mention.

Changes in the staff have occurred as follows: Dr. F. E. Clark resigned in the summer to assume the duties of the professorship of Chemistry in the Central College of Kentucky at Danville, and Mr. A. S. Shoffstall resigned in the early fall to accept a commercial position with the Eastern Dynamite Company of New York. The position rendered vacant by the resignation of Dr. Clark we were able to fill by the promotion of Mr. J. B. Churchill, whose services to the College have been conspicuous during the six years of his connection here, for unfailing loyalty and incessant labor. Still further, we had in Mr. M. J. Rentschler the right man to replace Mr. Churchill, and I am grateful to you and to the Executive Committee for approving the promotion of these two deserving men and placing them both on a five year contract whereby each will have the benefit of a year of study abroad within the five year period and thus be enabled to render still more efficient and valuable service in the future.

To fill the vacancy in the quantitative instructorship, caused by the departure of Mr. Shoffstall, we were able to secure the services of Mr. A. H. Roop, who was favorably known to us because of services rendered when he was formerly a member of our force; and to succeed Mr. Rentschler in the lowest position we were authorized to employ Dr. R. N. Maxson, an alumnus of the State College of Rhode Island and a graduate of Yale University, who came well recommended by the authorities of both institutions and has performed creditable service during the year.

Changes or improvements in the building have been made during the year at two points.

In accordance with a suggestion in a previous report, the four corners of the attic were built out during the last summer, in order to afford greatly needed supply rooms for the quantitative laboratory; Dr. Tuttle especially appreciates this convenience.

The Department of Mines and Mining having vacated the former assaying laboratory on our basement floor, this room was available for laboratory space, but was unfinished. By authority of the Executive Committee, I was permitted to contract for the fitting up of this room at an expense of $500 outside of Department resources. This was done in a plain but efficient manner and this new laboratory now accommodates a dozen or more men, according to the nature of their work. It was occupied immediately upon the opening of the second semester by seniors engaged in thesis work and will be needed for this work every year, enabling us now,

for the first time in several years, to attend to our graduation thesis work, without being compelled to send some seniors out to other departments because of insufficient room in our own quarters. The same laboratory will be used during the first half of each College year by sophomores in inorganic preparation work, thus affording a relief which was very sorely needed. I am extremely grateful to the Executive Committee for allowing me this expenditure for a laboratory to meet urgent demands.

I have devoted my last two Annual Reports chiefly to our need of a new building for Chemistry; these needs are remaining the same from year to year, as the number of students remains about the same; they will very perceptibly increase with any expansion whatever in our numbers.

At the opening of the present semester every place was filled and a small "waiting list" was established. So long as this waiting list remains small, with no more names on it than can be accommodated through the normal number of withdrawals which always occur within a few days or weeks after the opening of a semester, we shall have no serious trouble. But if this list increases, the capacity of our chemical laboratories will have been surpassed, for the last bit of flexibility has been reached, the last square inch of available space utilized.

I believe that my chief duty, at the date of this report, is to lay before you again the serious need, in which we stand all the time, of a larger fund for maintenance, as the source of the means of procuring current supplies of chemicals and apparatus, and also of increasing the teaching staff.

When, during the years 1893-1897, our numbers being yet small and our needs less manifold than now, the amount of appropriation to this Department, made available for current material supplies was $1,000 each year, we were properly taken care of in this respect; we moved along easily and without embarrassment. Necessary additions to stock could be made, though we could not afford any extensive developments. Yet the museum was started and student expenses were annually decreasing.

But when for the three years following, namely, 1897-1900, though our work was greatly expanding so that we required larger supplies and more available funds for material maintenance, we were obliged to get along with one-half our usual allowance ($500, $500 and $600 respectively), you will readily understand that we had to cut expenditures a great deal. All outlay upon the museum ceased entirely. Expenses of students remained about level, as it was not possible to further reduce them, a matter which has been a source of constant personal regret.

In the following year, 1900-1901, there was no appropriation to the Department for material needs, from any source whatever. The Department was paralyzed! Student expenses materially increased.

Then came three years, 1901-1904, in which the sums received for general expenditures were $500, $117.50 and $1,000 respectively. But during these years, we were obliged to enlarge our capacity very greatly; rapid increase of numbers compelled the occupancy of previously unused space and this was accomplished in three or four different stages as follows:

1. In December, 1900, the Executive Committee allowed the

Chemical Department $1,750 for constructing an organic laboratory under the physics lecture room. This accounts for the item "Additional Chemical Laboratory, $1,000," in the State appropriation of 1901.

2. In July, 1901, the Executive Committee allowed the Chemical Department $2,000 for fitting one-half the fourth floor for a quantitative laboratory.

3. Late in 1902, $1,735 were allowed for the other half and $500 for a recitation room. The work was accomplished with the sums mentioned *and with the maintenance allowances for the years 1901-1904.*

I insert the italics above, not to point out any fault of the Executive Committee in making too small allowances for the work that had to be done, for such did not exist. On the contrary, the Executive Committee did all they could do for us and more than we had any right to expect. They dealt generously with this Department at every point and I have nothing to regret except their absolute lack of funds. But I insert them to make it perfectly clear to you that the sums provided this Department for material needs, apparatus, chemicals, and miscellaneous supplies, had to be completely exhausted for co-operation with the Executive Committee in supplying the furniture for absolutely essential increase in our laboratory capacity, in order to make room for enlarged numbers of students.

Thus it was that for three years the Department had not one cent of money for supplies, not derived from charges upon students. Student expenses further materially increased. But this was not the worst of it. Increased laboratory space demanded increased equipment. Analytical balances, reagent bottles, platinum, porcelain, metal and glassware, locks and other necessary items had to be bought and all the money credited to the Department for the next two years, $1,000 for 1903-1904 and $1,000 for 1904-1905, was consumed in advance of our receiving it, for expenses of this character. In fact, $1,000 went for platinum ware alone at one purchase. Within the last year, further extension of our laboratory space has been generously allowed by the Executive Committee, as mentioned in the early part of this report, and the new laboratory for inorganic preparations and senior theses, again a matter of dire necessity, has cost nearly $600. This is clearly within my original calculation, though $100 in excess of the allowance for which I asked, and an estimate of $150 for the necessary equipment of the new laboratory is ridiculously small.

The appropriation received for the present year, 1905-1906, for general purposes, is $250, a mere pittance of course, but I am duly grateful for it and from what I know of their resources, I do not know how the Executive Committee could have done any more for us. Enough has been said to show that this sum has also been exhausted for expenditures incident upon the enlargement of laboratories.

I trust I have given detail enough to show that:

1. Prior to 1897 this Department had, with small numbers of students, $1,000 per year for general purposes.

2. From 1897-1900, with larger number of students and increased needs, we had $500 per year.

3. From 1900 to date, with almost overwhelming numbers for six consecutive years, we have had, to be sure, between five and six hundred dollars annually allotted to us for general purposes, but have been compelled *to exhaust it all* in applying towards new laboratory, office, recitation room and for equipping the same for daily use.

At present we have to meet, aside from regular supplies of apparatus and chemicals, the expense of:

1. All additions to chemical library, including subscriptions and bindings.
2. All freight, express charges, hauling and altogether too much repair. As an allustration of the latter, all our window shades at the front of the building, where they are indispensable for our work, must now be replaced. The assaying room was released to us with all shades carried off, fixtures and all; the rooms in the attic have never been supplied with shades; and those in the laboratories have literally fallen to pieces. The sun makes these shades necessary at this time of year, and regarding the matter as one of repair, I applied to Mr. Patterson. Meeting with the usual response, I am compelled to order them without longer delay, to be paid for out of the Department funds, unless otherwise provided, which is now improbable.
3. Stenographer and all other office expenses.
4. Assistance to several needy but worthy students.
5. Cost of inspection trips, now come to be a necessity, and no insignificant item annually.
6. Necessary printing.
7. Frequent purchases of hardware and pipe fittings.
8. All development of Department work along whatever lines.
9. The work of class experimentation in lecture room and laboratory.

In addition to the above, we work continually under the great handicap, whereby our constant efforts to reduce student expenses, and place chemists on a level, as regards laboratory charges, with students in all other departments, are perennially defeated.

I feel certain that I am keeping within very modest limits, when I urge that the resources of the Departmnt for material supplies, wholly aside from the salaries of instructors, be placed at no less than $2,500 annually, over and above all collections from students in the Department.

An additional instructor is also a necessity. This was urged in my report of a year ago, and again in a special request in the winter, but had to be declined. I have felt very uncertain about the possibility of our carrying the work through the present semester, with every man so crowded with duties as has been the case. But I think we can see our way through now, though the work of this semester has not been as thoroughly done as it should be. For another year, however, in the second semester at least, an additional member of the staff seems to me an unavoidable necessity.

I hope therefore that the appropriation for this Department allowed by the next legislature will be sufficient to provide:

1. For all necessary aid in meeting the present salary roll, with reasonable increments.

2. One additional instructor.

3. A residue of $2,500 per year to reach the Department for general purposes.

I do not know what will be the method of apportioning amounts among the various departments, and I certainly have no desire to ask for any unfair proportion whatever; but I might perhaps be permitted to mention a few pertinent facts as having a possible bearing:

1. This Department probably reports grades for more hours of work than any other which is a regular applicant for annual appropriation.

2. In addition to work with our specialists, we have to give instruction to every student in College.

3. This Department has graduated some fifteen per cent. of the present Alumni roll of the College.

4. This Department stands fourth in the College, as regards number of Alumni graduated since our present technical courses began, and no Department has graduated twice as many men as we have during the last fifteen or eighteen years. The proportion of graduates in the three departments which outstrip us in numbers is as:

1.8 graduates of course x to 1 graduate in chemistry.
1.6 graduates of course y to 1 graduate in chemistry.
1.3 graduates of course z to 1 graduate in chemistry.

5. We have not been able in the past, owing to the lack of funds, to purchase equipment enough to keep us abreast of the times as we ought to be.

Thanking you for courteous treatment in the past and bespeaking your kind consideration of these requests, I am,

Very respectfully,

G. G. POND,
Professor of Chemistry.

May 28, 1906.

V.—ENGINEERING.

State College, Pa., May 22, 1906.

To the President:

Sir: In order to present the effect of increased attendance upon the College work in the departments which have to do largely with the upper classes, it is fairer to compare the upper classes of the present time with those of a few years ago than to compare total attendance.

In 1900 men were graduated from the College by schools as follows:

Language and literature,	3
History and political science,	1
Agriculture,	3
Natural science,	8
Engineering,	27

While in 1906, this year, there should be graduated by schools:

Language and literature,	2
Agriculture,	3
Natural science,	14
Engineering,	74

It will be seen that in the Engineering School the Senior class of this year is about 274 per cent. of what it was six years ago. The result is that it has been necessary to divide the classes into sections and the call for duplication of equipment has been much greater than could be met.

This tabulation shows further that 80 per cent, of the Seniors are engineering students. The percentage of engineers in the Junior class is fully as great. When it is realized that practically all of the Junior and Senior studies of these men, with the exception of work in Political Science, are taught in the Engineering School, that is in Class Room, Drawing Room, and Laboratory of the Engineering Building, some idea may be gained of the crowded condition which prevail there.

Heretofore it has been possible to use the higher class Drawing Room for Freshman overflow. This is no longer possible as the Drawing Rooms for the higher classes are now inadequate to meet the demands of their own work. The result is that we are obliged this year to take care of about 225 Freshmen in a Drawing Room that properly accommodates 38 men. This has been done by crowding two or three men on a table at a time and using the same tables

for several sections although none of the tables accommodate more than one set of instruments and appliances.

The square feet of floor space now given to Freshmen Drawing is 1,479. In this connection I might add that in looking up the amount of floor space allotted by different institutions to Freshman Mechanical Drawing I find that for our number of students the average floor space given to the Freshman Drawing would be about 5,000 square feet. The total amount of floor space which is devoted to Drawing—for Freshman, Sophomore, Junior and Senior work—in the Engineering Building is 7,540 square feet. The average floor space devoted to the same kind of work in a number of technical institutions is—in round numbers—12,500 square feet, for equivalent numbers of students.

With the usual increase in attendance next year it will be impossible to make proper provision for the Drawing in the Engineering Building. The only practicable resource would seem to be to find some other place for the Freshman Mechanical Drawing until the Engineering Building can be extended. If the Freshman Drawing were moved to the Main Building and drawing tables provided which would accommodate four different sections—that is, tables having separately locked places for the equipment of four students—a floor space of 3,000 feet would answer the requirements. With the Freshman Drawing taken from the Engineering Building, the present Drawing Rooms would meet the immediate requirements of the higher classes.

The Mining Engineering Department now occupies its new quarters. Unfortunately this change has not relieved to any great degree the congestion in the Engineering Building. It gives two much needed class rooms but the most crowded condition is in the Laboratories and Drawing Rooms and the withdrawal of the Mining Department has not relieved this difficulty.

At present the instrument room for the Civil Engineering Department is on the third floor of the Engineering Building. This necessitates carrying up and down all the instruments used in the Surveying and Field work. These instruments should be kept on the first floor but up to this time it has been impossible to find a place for them.

(a.) MECHANICAL ENGINEERING.

The work of the Department of Mechanical Engineering has been handicapped for a number of years by the frequency with which it has changed instructors. Every year a number of teachers are lost because they are offered larger compensation elsewhere. This year promises to be no exception to the rule; at least four men in the Department have been offered considerably more than they are receiving here. It takes some time for any man to accommodate himself to new conditions and surroundings and the value of a good teacher increases year by year.

Considering the serious interruptions and the crowded condition of the Department, the work has been satisfactory.

Mechanical Laboratories.

In the Mechanical Laboratory the crowding has been serious and next year it will be much worse. In the fall term of next year there

will be three Senior Mechanical sections as against two this year; three Senior Electrical sections as against two this year; and in addition to these, under the new schedule of courses there will be five sections of Junior Electricals to report two hours a week. This will require eighteen hours a week instruction in the Mechanical Laboratory in addition that which was given last year.

In order partly to meet the need for space I would suggest that Room 11, which is now used as a Mechanical Museum, be taken as a part of the Laboratory. The display that is in this room can be placed in cases in the hall-ways and in recitation rooms and with an arch or door cut between Room 11 and Room 12 so that Room 11 will become an integral part of the Laboratory (Room 12) the work can be conveniently handled and the crowded condition temporarily overcome. It is to be regretted that the Mechanical Museum should be broken up in this manner but it seems the only possible expedient in order to accommodate next year's students. During the past semester we have been obliged to put tables in the halls in the Engineering Building in order to carry on the work.

The course in Hydraulic and Sanitary Engineering, and the short Agriculture Course call for work in pipe fitting. We have no place at present to give to this work. During the past year a part of the Fan Room in the Engineering Building was used but this space is neither adapted to the work nor sufficiently large.

Shops.

Each year the Engineering students in the higher classes are taking more interest in their thesis work and, as many of the subjects are such as require considerable actual construction, the use of the shops is becoming more and more a necessity to the upper classes. Special provision should be made for shop thesis work. Under present conditions, it is impossible to accommodate it properly.

During the past two years the students have designed and built in connection with their thesis work a 20 H. P. high speed engine with a direct connected generator which, commercially, is worth $700. This is a valuable addition to the Laboratory. They have produced also a number of other appliances of commercial value to the shops and laboratories. The interest the students have taken in their work and the results which have been secured in the shops is gratifying, and the lack of space and equipment is a serious menace to this important side of the higher class work.

Steam Plant.

I cannot speak too highly of Mr. Gentzel's work on the Steam Plant during the past year. His appreciation of the desirability of economizing whenever possible has made him especially valuable. During the present year a great many repairs have been made upon our machinery and upon the plant generally; engines have been overhauled and piping readjusted. The daily records of the coal consumption give evidence of this care. There remains, however, considerable work that can be done without great outlay which would be a decided saving in maintenance of the Steam Plant.

An effort has been made to eliminate the use of high pressure steam in the tunnel. The only places in which high pressure steam

is required are the Dairy Building and the Chemistry Building and it would seem that it should be possible to remove the necessity of its use at these two places except occasionally when special work is being done.

If it is essential to have high pressure steam at all times in the Dairy Building, some provision should be made for its generation near that point. The quantity used is so small that the loss in transmission is relatively very great. A small boiler house should be erected near the present Dairy Building for use during the spring, summer and fall months, especially. The cost of such a plant would be comparatively small and the economy during the part of the year when the large plant is practically closed would be very great.

At present, in order to protect the College against coal strikes and other contingencies it is necessary to have a large stock of coal piled outside of the Engineering Building. This is not only objectionable from an economical standpoint but for many other reasons. Our coal house should be enlarged on the lines proposed in the plans presented for the extension of the Engineering Building, with coal conveyors to carry the coal from dump to boilers. This improvement would save in labor annually at least 15 per cent. of its cost, and would thus greatly reduce the maintenance expense of the heat and light plant.

A detailed report upon the need of the Steam Plant has been presented to the Executive Committee.

I fully appreciate, Mr. President, that you have done everything in your power to alleviate the crowded condition of shops, drawing rooms and laboratories in the School of Engineering and beg to express my gratitude to you for helpful suggestions and encouragement which at times have made it possible to accomplish results which seemed impossible.

Respectfully submitted,

LOUIS E. REBER,

Dean, School of Engineering.

(a) CIVIL ENGINEERING.

To the President:

Sir: I have the honor to present the report of the Department of Civil Engineering for the year now coming to a close.

The teaching force of the department has remained the same as last year with one exception. Mr. Donald Derickson, Assistant during the previous year, resigned his position at the end of the year to accept a similar one at Cornell University and Mr. F. A. Gorham of our class of 1905 was appointed to fill the vacancy. Unfortunately Mr. Gorham has decided not to remain with us another year, having received an appointment to the position of Aid in the Reclamation Service of the U. S. Geological Survey, as the result of a competitive civil service examination. As heretofore, we have been obliged to obtain some assistance from members of the upper classes in teaching Surveying to the large number of Freshmen.

With slight modifications in details the work of the department has been conducted on the same lines that have proven satisfactory in previous years. The old schedule has been followed in the work of the two upper classes while it has been possible to follow the new schedule, based upon the advance in entrance requirements, with the two lower classes. While the time available for advanced technical work has been increased by the recent change referred to, it is hoped that it will be thought wise to still further advance the entrance requirements in the near future by the addition of Trigonometry and one modern language as in many other technical institutions.

The option in this course offered for the first time this year to such students as desire to specialize in Sanitary Engineering is being chosen by quite a number of men, showing that there is a decided demand for such a course.

The Hydrographic Summer School was again held at Eagles Mere as in the previous year. This point furnishes the most favorable locality within easy reach of the College for the work in question. If it were not for the fact that it is necessary to utilize the still water of the lake for rating the current meters, all this work could be done at some point on the Susquehanna river, much nearer the College and more favorable in other respects. By the expenditure of a comparatively small amount of money, a channel could be prepared and the necessary apparatus installed at the pond near the reservoir on the Campus where meters could be satisfactorily rated.

Permit me to again call your attention to the crowded conditions prevailing in the rooms of this department. It is true that the removal of the Department of Mines and Mining from the Engineering Building has given us slight relief in the way of another office room and the partial use of another class room, but the main difficulty is due to the lack of sufficient drawing room and laboratory space, and this has not been increased.

The demand for graduates of this department continues to exceed the number available, some of the men in the present Senior Class having had several positions offered them.

A very large proportion of the undergraduates in this department spend their summer vacations in engineering work and this proportion is gradually increasing. This I consider a very favorable indication, as the taste of practical work gives students a broader view and enables them to better appreciate the advantages of their college training.

I will close this brief report with an extract from a letter written to me by a prominent official of one of the largest industrial establishments in this country where many of our graduates are employed. After making a favorable comparison of the work of our men with that of men from other colleges he says, "What is more, they are a manly lot of fellows. I congratulate you and your associates on the record."

Respectfully submitted,

F. E. FOSS,
Professor of Civil Engineering.

State College, Pa., May 23, 1906.

(b) ELECTRICAL ENGINEERING.

To the President:

I have the honor of presenting to you herein, the twelfth annual report of the Department of Electrical Engineering.

There are enrolled in the College catalogue something over two hundred men who are taking the Course in Electrical Engineering, which shows a continuance of the rate of growth of previous years. Twenty-six men will be graduated from the department this year—the largest class so far graduated in its history. At the beginning of the second semester there were thirty-seven men in the class in Dynamo Machinery. This would indicate that a section of at least thirty will be graduated in 1907. The size of the Sophomore section indicates a still larger number of electrical graduates for 1908.

Professor H. P. Wood has been especially successful in systematizing the work of the electrical laboratories and has brought them to an efficiency not heretofore reached. He has been ably assisted in this work by Doctor R. E. Myers, Mr. A. R. Dennington, Mr. E. E. Godard and Mr. Myron Creese. What has been done however, along the lines of laboratory work has been in the face of excessive difficulties due to lack of suitable equipment. Indeed, of the eight or ten institutions in the United States having the highest enrollment of students in Electrical Engineering, of which this is one, none are so deficient in the facilities for electrical experimental instruction and research as are we at this College. Doctor Myers though especially handicapped in the Electro-chemical Engineering Laboratory, has been steadily and gradually developing his work until it is taking an important place in the Department. His is a class of work which can well be developed more fully. It is wise to add here that there is danger of our losing all the men named above this year unless their salaries are raised to a point more commensurate with the character of their work. At least two of them have already received quite flattering offers and I understand that overtures have been made regarding the others. It is impossible to hold strong instructors in electrical engineering on the same scale of compensation as may be adopted by colleges devoted to literary and non-applied scientific work, as available commercial positions are too numerous and attractive.

There have been more applications for our electrical graduates from industrial concerns this year than ever before in the history of the Department. Most of the men were suitably placed as early as February and will report for duty shortly after commencement. All and many more could have been placed at as early a date, but in some few cases they preferred to delay making a contract. I see no reason why the number of students in Electrical Engineering cannot, with the present call for men, increase to five or six or more hundred and all the men who are able to complete the course obtain suitable positions without difficulty.

The school organizations that the trustees adopted some years

ago have been of the greatest possible service in promoting the work in electrical engineering as they have brought nearly all the technical interests together in the School of Engineering and have done much to enable us to improve our methods of teaching, and have given us a better opportunity to deal intelligently with the cases of individual students. I believe that still greater advantages would be derived by placing increased responsibility upon the schools, under such restraint, of course, as is necessary for the proper correlation of the College work as a whole.

In the electric light plant a more than usual effort has been made this year to cut down the unnecessary use of electrical energy. The greatest difficulty in reducing waste in this direction, is in the dormitories occupied by students. Many are in the habit of leaving their lights turned on from early evening until bed time whether they occupy their rooms or not. This difficulty is inherent in all electric lighting installations, whether owned by private corporations or otherwise, where the charge is per light instead of for the energy actually consumed. I have already recommended to you a scheme for installing meters whereby the waste may be reduced to a minimum. The plant is being strengthened in its weak points wherever possible with the funds made available by the last Legislature for rewiring purposes. The underwriters' inspectors have accepted all the buildings on the campus, but in some cases changes and improvements should be made to insure the highest degree of safety. Most of these changes will be accomplished before the end of next year with the funds now available. The power plant itself should have a new generator installed to replace the old Edison machine still in intermittent use. Such a substitution would not only add to the stability of the plant, but would also add to the economy. The cost of this generator complete would be about $1,000. A complete watchman's time detector system has been installed which covers all the buildings of the College plant. This is a much needed and efficient protection against fire losses.

The work of the students in the Department this year, though disturbed by many unusual breaks in the fall semester, has been fairly good and is now unusually vigorous. Indeed, at the present time the men with whom I come in contact in class and laboratory, are working harder, taking more interest in their studies, and in general have a better attitude toward their work and surroundings than has been the case for a long time. This quick recovery from disturbed conditions to a state of high efficiency is undoubtedly due to the wise and enduring principles which you have laid down for the conduct of the Department under my charge and the College work in general. The results of this conduct are clearly evidenced in the insistent call by industrial interests for our graduates and in the continued growth in student numbers; or in general, in the rapid upbuilding of a great institution of learning under conditions which, when you came here in 1882, seemed hopeless.

I thank you for the kind assistance you have always rendered me in my work both personally and officially.

Respectfuly submitted,

JOHN PRICE JACKSON,
Professor of Electrical Engineering.

State College, May 18, 1906.

(d) MINES AND MINING.

To the President:

Sir: I have the honor to present to you the following report relating to the Department of Mines and Mining for the year 1905-1906.

The past year has been one of the most important in the history of the Department, owing to the generous efforts of the president of the Board of Trustees, Judge James A. Beaver, aided by other members of the Board and various other public spirited citizens to give it a home. Through these efforts, last August ground was broken in order to commence the erection of temporary buildings for the Department.

Any change of this kind is a great advance, for before this, the Department was living in dismembered sections in four scattered buildings, in all of which it appeared but as an annex to larger and more important interests in those buildings. No one in looking over the work here could possibly draw any other conclusion at that time than that the Department of Mines and Mining was at the extreme fag end in the list of courses, instead of in its true position as the fourth largest in the institution.

While much more pretentious buildings could be desired, yet successful work in a department, does not apparently depend so much upon its buildings, provided sufficient room can be had, as it does upon the teaching force and its equipment.

More accommodation for the growing work of the Department and the increased size of its classes was imperative and the effort to provide for it has eventuated in the commencement and partial carrying out of the following plans: The building employed for the Mineralogical Laboratory was moved upon a vacant plot of ground, southwest of the depot and the Engineering Building. This two-story building was extended to the distance of 170 feet giving room on the first floor for a Mining Laboratory, a Mining Lecture Room, a Metallurgical Lecture Room, and the necessary hall and instructors' rooms. The second floor contained the Mineralogical Laboratory, a Geological, Paleontological and Petrographical Laboratory, and a Geological and Mining Lecture Room, besides the instructors' rooms. This part has been sufficiently completed to allow of its being occupied by the department on the first of April. A one-story wing to be 40 feet wide and 190 feet long extends westerly from the southwest end of the building. Of this some 60 feet have been built and occupied since last November for the Metallurgical and Assaying Laboratory. The remaining portion when built will be occupied for Metallurgical purposes and for a Coal Washing and Ore Dressing Laboratory.

Another wing 40 feet wide two stories high and 100 feet long is to be built westerly from the northeast end to take care on the lower floor of the Mining Exhibit and the other exhibition material, while the upper floor will be used for laboratory and lecture purposes.

Both these extensions are imperatively needed, as the Mining Laboratory can not be used for its legitimate purpose until room can be had to remove the material belonging to the Ore Dressing Laboratory and Exhibition Room, now stored there. In the same way it is important to relieve the congestion in other buildings by removing material pertaining to this Department into these prospective wings.

The work of the Department requires that all these buildings be completed this summer and properly equipped before the middle of next September. This is justified by the growth of the Department which during the past year has enrolled 114 students, although the catalogue shows only 98.

The enrollment for the past thirteen years so far as known is as follows:

	1893-4.	1894-5.	1895-6.	1896-7.	1897-8.	1898-9.	1899-00.
Catalogue numbers,	9	21	23	23	19	20	22
Total number,	.....	.....	.....	.....	.....	.....	.....

	1900-01.	1901-02.	1902-03.	1903-04.	1904-05.	1905-06.
Catalogue numbers,	27	21	45	67	81	98
Total number,	.....	26	52	73	88	114

During the year 1905-1906 instruction has been given in the following subjects and to the number of students specified below:

	First Semester.	Second Semester.
Crystallography, mineralogy, and petrography,	103	88
Principles of geology,	46	.....
Mining geology,	28	30
Coal mining,	20	.....
Ore and stone mining,	.....	28
Mining engineering,	13	13
Mining laboratory,	14	16
Mining law,	.....	15
Assaying,	41	.....
Metallurgy, junior,	28	16
Metallurgy, senior,	21	24
Metallurgical laboratory,	15	34
Principles of metallurgy,	.....	100
Ore dressing and coal washing,	8	.....
Paleontology,	.....	3
Field geology,	.....	13
	337	380

The summer school in Mining Surveying and Mining was conducted at the mines of the Adena Coal Company under the direction of Mr. E. N. Zern, instructor in mining and mineralogy and Mr. George H. Deike (class of 1903) assistant superintendent and mining engineer for the company.

Mr. Zern, to my deep regret, resigned at the end of last year to enter practical work after two years of faithful and efficient service here. Mr. H. C. Ray, who had been a most able assistant in Mineralogy and Metallurgy during last year, also resigned to take up practical work.

The vacancies left were filled by my assuming part of Mr. Zern's work and by the appointments of Mr. L. B. Smith an assistant in Mineralogy, Mr. F. A. Dalburg as assistant in Mining and Metallurgy and Mr. R. P. Farrington as assistant in Mineralogy and Metallurgy. Very much of whatever success has been attained by the department has been due to their energetic and efficient work. Mr. C. P. Linville, who has been the instructor in Metallurgy for the past three years, is entitled to great credit for his hard and pains-taking work that has resulted in so rapid a development to the Metallurgy, that there is but little doubt that the new Metallurgical Laboratory will have to be enlarged in a very few years.

The practical summer school work in mining and allied work has been successfully continued. The students have been in the employment of various companies like the Delaware, Lackawanna and Western Railroad Company, H. C. Frick Coke Company, The Red Run Coal Company, Pennsylvania Railroad Company, McInnes Steel Company, The Rochester and Pittsburg Coal and Iron Company, Clearfield Bituminous Coal Corporation, Jas. G. Corcoran Company, and Lehigh Valley Coal Company.

Opportunities such as these are extremely valuable in the training and education of the student, in demonstrating to him the essential union of theory and practice.

Respectfuly yours,

M. E. WADSWORTH,

Professor of Mining and Geology.

May 28, 1906.

VI.—ENGLISH AND RHETORIC.

To the President:

Sir: The work of the Department has been little changed since my last report. The greater part of the work has been as usual the rhetoric of the freshman year, and the aim has been as ever to give those who take it, nearly all of them in the technical courses, as practical a drill as possible in the simple English composition which will be required of them as business men. Little else can be attempted with freshmen who have had almost no linguistic training even in their own language, and who have read and studied no literature outside of the four required entrance classics. The instructor can only insist upon constant exercise of the art of composition; daily themes carefully criticised; and weekly themes thoroughly corrected and if need be rewritten until satisfactory. The work of formal college rhetoric, the applications to literature, and the higher branches of style, he must pass by completely, while he corrects spelling, faulty sentence structure, incoherent thinking, awkwardness and wordiness, and incorrect paragraphing. And he is to be satisfied if he can bring some degree of correctness to his student's pen, and some small increase in facility and force.

I wish to confine my report, Mr. President, to one single aspect of our department work, and to present to you a problem which I am sure you have long been considering. Out of the 269 men who took the rhetoric of the first semester 46 failed to complete the subject, not counting the ten or twelve who dropped out discouraged before the examinations. This failure was owing to no lack of supervision. Each man had been told his exact condition in all subjects at the end of each month of the semester. In addition each instructor in the department had given extra time to these weak men, had warned them and counselled them and pointed out their specific weaknesses. In almost every case the man failed after both he and his instructor had done their best. The secret of the failure lay in the fact that the man should never have been allowed to begin the work, and the remedy in my opinion lies in cutting remorselessly from the list of fitting schools from which we receive certificates all those schools who send half prepared men vouched for as prepared. Nearly every one of the forty-six men who failed in their English entered upon a certificate signed by a principal of a school certifying that the bearer was fully prepared to enter upon the regular college work.

I can make it clearer perhaps by quoting from actual written exercises done by freshmen. The school principal certifies that the man has made a most excellent record in his English and that he is fully prepared to take up advanced college work. The Department knows nothing of the man until it finds him in the class the first day. At the end of the week the man brings in his first theme

carefully prepared in his room. Let me quote from one such verbatim and literatim:

"In the first place wholes are dug where steaks are to be placed. After thirty or fourty of these wholes are finished and the lumbermen has distributed the poles the poles are then raised in a vertical position by ten or twelve men depending on the seize of the poles. The raising of these poles is very dangerous work for the poles rests upon the pikes which are held by the men and if any of these pikes should break as they often do it endangers the life of all those who are under it."

This sample I have taken quite at random. By making a search among all the themes and exercises I could find dozens much worse, some indeed so bad that should I reproduce them I should hardly expect to be believed. Hardly one of the forty-six who did not produce themes as bad as the one quoted above. Let me give random selections from the writings of these men:

"By the time we were at Lemont there was about seventy-five of us and they were all crowded at the doors and when the train stoped the Sophmores made a rush for the hacks. I was a little slow in finding the man that took charge of the trunks to give him my check and therefore was compelled to wait about an hour for there wasnt enough hack to accomodate them all and there was about twelze of us had to wait untill the hack come back for us. We arrived at the college between half past six and seven oclock and all I done that night was regester so that I could get my key to get in my room and seeing to getting my trunk took to my room."

"I decided to come to "state college" because it offered the following advantages firstly a thorough preperation of the course elected, its pleasant and healthy situation and lastly it provides for its graduates good reliable positions commanding good salries."

"On entering your eyes will first rest on the ceilings being adorned with spider webs of all descriptions, the walls may have saw paint already but you can't hardly notice it at once glance of the eyes, the room is about ——," etc.

"This particular Cabin is located about half a mile up in Shingletown Gap. The plase has been chosen for it on account of the beautiful plase, and the supply of good water that is near it, also on account of the convenience of the plase for the campers, to get to.

"The Cabin is situated in an almost open plase of about half an acre. There has been a couple of trees left standing in front of the Cabin for shade, and for a plase to set and read or have a small lunch out doors. A drive road leads up to the side of the Cabin, and there out to some trees where there is a plase for standing and feeding horses.

"There is but one small door for entering the Cabin, which would make it appear to a stranger as a jail or a lockup because the sides seem to be bourded up solid, and with but very few small windows," etc.

After much criticism and writing and rewriting, the author of this last theme got his work into the following form:

"The cabin which I am to describe is located about half a mile above the entrance of Shingletown Gap. The site was undoubtedly chosen because of the beautiful surroundings, the abundance of good water, and the easy accessibility for campers. About it there is

an open space of nearly half an acre and in front of it for shade and shelter are two large pines. There is a drive-way to the front door and on by it to a grove of hemlocks, where there is a place for hitching and feeding horses.

The style of the cabin is peculiar. There is but one small door, and the sides seem to be boarded up solid with here and there a small window, all of which makes it appear to a stranger like a jail or a lock-up."

But it is useless to try to lay foundations in such elementary subjects after one has entered college. One hundred and twelve hours is all too short a time to make over a man's English if it has been almost totally neglected until he has entered upon his college course. Such men are doomed at the start. Five years of constant training would be all too short for some who have entered vouched for as prepared. Language cannot be learned in a day or a week or a freshman year. One may tutor up his algebra in four weeks but not his neglected English.

The English that a man writes is to a large degree an index to his mental powers. With hardly an exception the forty-six men who failed to pass the rhetoric failed also to pass in one or more of their other subjects. The college cannot in a few hours during a single freshman year do all the neglected work of the earlier grades and make one who writes English like that quoted above into a finished scholar upon whom she is willing to place her stamp, for after the freshman has completed his rhetoric the Department sees no more of him until he comes up to have his diploma signed. What he is in English at the close of the rhetoric course he is at the close of his college course three years later.

There are in my opinion but two remedies for this evil: either grant more time for English teaching, or else modify the present system of entrance. The former, however, is not possible at the present time; the latter seems to be the only practical remedy. Manifestly if the Department were allowed to test, at entrance, the English of each candidate, it could rule out at the start the forty or fifty men who are perfectly sure to be dropped at the close of the first semester. The gain would be two-fold; it would not discourage the unprepared student as the present method does and force upon him the conviction that he is forever unfit for education, and it would relieve the college divisions of the dead wood that so clogs the work of every instructor who deals with the freshmen during their first semester.

Some fitting schools always send good men. These institutions should be allowed to give certificates. Then too each school which for a year or more has sent men who are well prepared, should be added to the list, but all schools which at any time have vouched for half-prepared men should be dropped at once. This, Mr. President, seems to me to be the only remedy for an evil which has been growing steadily for the past six or eight years.

Respectfully submitted,

FRED LEWIS PATTEE,

Professor of the English Language and Literature.

May 28, 1906.

VII. GERMAN.

To the President:

Sir: It is a pleasure to report that in the eleven years of an unbroken administration the work of the department has never been more prosperous than during the current year. The percentage of failures has never been so low. In the Junior and Sophomore classes, consisting of seventeen and twenty-four students respectively, there was during the First Semester not a single failure to report. In the Freshman class the number of failures for the same period was only 14 per cent., the lowest record yet made.

This remarkable showing, we believe, can be explained on the following grounds: 1. About 75 per cent. of the students had had some German before entering. Now, as German is taught in nearly all the preparatory and high schools throughout the State, there would be less difficulty in requiring one year of some foreign language for entrance than there was in the case of Solid Geometry a few years ago. When this requirement is made, a year's course in advanced German should be filled into the hours thus left vacant. 2. Our system of monthly reports and warnings to students below grade has much to do in reducing the number of failures. The effect of this system is two-fold: it weeds out men too weak and indifferent to maintain standing and it is a salutary stimulus to such as are not doing their best. 3. An additional reason for the low percentage of failures lies in the excellent qualifications of the assistants in this department, namely: Miss L. V. T. Simmons, who by her industry, ambition, and scholarship earned the degree of Master of Arts, which the College conferred on her last June; and Mr. F. A. Hilary, whose services are especially valuable by reason of an experience of fifteen years including several spent in study and travel in Germany, France and Italy. It is earnestly hoped that the Trustees will express their appreciation of the value of these instructors in a manner as to make it possible to retain their services.

The call, this year, from ten students for a class in Scientific German and for another in "Faust" as extra work, together with last year's two candidates for the Master's degree in modern languages, gives evidence of a growing interest in German that ought to be met with a generous provision for the books in the library so much needed for advanced work.

The most crying needs of this department are increased salaries and more books. It should be remembered that the salary of to-day does not go so far as it did seven years ago. With the increase in living expenses there has been no corresponding advance in salary. To engage in additional pursuits not germane to the profession of teaching and thus divide the attention that should be wholly given to the work in hand, though, very undesirable, has nevertheless become an absolute necessity.

It is to be regretted that so little heed is given to the call for a few books that this department needs. No department in language and literature can flourish without a suitable library. The instructors are too poor themselves to buy the books that properly belong to a library; and yet with no library at their command they are expected to do work of like kind in other institutions of the same class.

Respectfully submitted,

CARL D. FEHR,
Professor of German.

May 28, 1906.

VIII.—GREEK AND LATIN.

To the President:

Sir: My college duties have changed so completly within the last seven years that now the larger part of my work is outside of what concerns this Department. My time, the whole cast and trend of my thought, and nearly all my reading, have been engrossed with subjects very far removed from class-room work in Greek and Latin. I call attention to this fact, since it may have made some difference to the special work of my Department, though I hardly think so. The weakness of the Department finds a ready explanation.

The fact is that the systematic and long continued attack upon Greek, and to some extent upon Latin, has succeeded in shelving most effectually the Greek and may gradually have a similar effect upon the Latin.

At a recent meeting of the principals and teachers of New England classical schools, the head of a venerable and conservative academy of national reputation stated that, of the entire body of nearly three hundred students in his school, only six were studying Greek. In that same school, twenty years or more ago, the number of students in Greek was nearly equal to those in Latin.

A leading firm in New York City has recently published Latin Lessons, one feature of which is worthy of comment—an introduction containing an epitome of the general principles of English grammar. This has been deemed wise because of the feeble grip upon the principles of English grammar which pupils, as a rule, have at the outset of their study of Latin. This goes to show that the relaxation of the systematic study of Greek, and somewhat of Latin, grammar has led to the minifying of English grammar. The irksomeness and apparent uselessness of the formal and technical study of the grammar of Greek and Latin has asserted itself within the bounds of our own language. "Sight-reading" in Greek and Latin for which there was such a craze but a few years ago is repeated in our own tongue by "language lessons" which do away, as far as possible, with formal grammar and which endeavor also to render the spelling of words and the learning of the alphabet unnecessary.

I have not the presumption to give an opinion upon a matter which the public has taken into its own hands, or to say whether the dropping of these older studies is wise; but, of course, as they have been the principal branch of scholarship to which my life as a teacher has been devoted, I can confess to a selfish pain as I have seen the old ground gradually shocked from under my feet.

The past declares, however, that the pendulum will swing back again. Human nature loves what is excellent and will, in time, always return to it. There have been many Renaissances. When the hurry of our busy age has ceased, when the practical things which

are so many and so necessary shall have reached the full tide, when man shall have time once more for quiet contemplation, the languages which have left us rich and almost faultless memorials of literature and of grammatical formulas cannot fail to reassert themselves. They will again come back and assume the throne, and give out laws and assert their influence in correcting the thought and expansion of civilized men.

This general reference has seemed to me almost a necessary part of my report. What work I have had this year in this Department has been entirely in Latin and the year has passed hapily and profitably. I have given instruction in the De Officiis of Cicero, the Morals of Seneca, the Captives of Plautus and the Andria of Terence.

Yours very truly,

BENJAMIN GILL,
Professor of Greek and Latin.

May 28, 1906.

IX.—MATHEMATICS.

To the President:

Sir: I have the honor to present the following report for the Department of Mathematics:

The year just closed has witnessed the complete inauguration of the new schedule of hours for this subject. Last year the same schedule was put into operation—on crutches so to speak. This year it has been fully carried out without making any irregular arrangement of work.

By the new schedule all courses have a continuous block of time allotted to the Mathematics, from the students matriculation till he leaves our work. It is perhaps too early to generalize extensively on the results, and the adaptability of this programme to our needs, but certain considerations will not be out of place:

(1) The assignment of a continuous time and regular number of hours per week for subjects so markedly consecutive as the mathematical subjects included in our technical courses has proved, as anticipated, very satisfactory. I doubt if it would be possible with our large classes and special scheduled students to administer the courses as well in any other way. If we could also count on the same hour during the day for each separate class or section to recite, the student would be further convenienced and the work would be more easily and regularly done. As it is, a single class in mathematics may recite at a different hour every day. This makes little trouble in the matter of instruction except in the arrangement or crossing of irregular schedules; but the regularity of an eight, or nine, or ten o'clock hour in mathematics would be to the run of men of infinite significance.

This arrangement was measurably enjoyed till the large increase in the number of students forced the scheduling of practicums "by arrangement," at the particular laboratory, and at irregular hours as they were available. Not only is our present schedule thus made inflexible, when a new section must be made or when an instructor falls sick and sections must be shifted; but there is coming to be a confusion in the necessary distinction between work which must be prepared in advance and upon which outside study is necessary, and other work which may be done under the eye of an instructor and ought to be completed there.

(2) Special care on the part of the registrar with reference to certificates in Solid Geometry, recently required for admission, and his extensive and precise correspondence with reference to it, have contributed to reduce the number of conditions this year in that subject, as well as increase the ease with which those given have been made up.

On the other hand the preparation in Plane Geometry, Algebra and Arithmetic show no improvement and are a handicap to college work generally; so much so that it seems to me that some modifica-

tion of the certificate system ought soon to be made. The instructors in several Departments outside my own have remarked recently upon the somewhat unsatisfactory preparation secured in these branches.

Complaint is not made as to the more difficult parts of the subjects, but because the men cannot be depended on to perform correctly the very simple operations in Arithmetic; such as addition, multiplication and division of integers and common fractions. In Algebra men cannot solve simple equations and they pile up symbols without being able to perform the operations indicated, and are ignorant of the fundamental definitions and principles employed. Abundant proof and particulars can be given to support these general statements.

Possibly the College has come to the point when it should make a careful canvas of its list of accredited schools and refuse ultimately to consider certificates from those whose students prove to be imperfectly fitted.

If thought wise the faculty might be asked to print in the catalogue a limited list of schools that would be allowed to recommend absolutely through their principal for our Freshman standing. Such a list should include the State Normal Schools and might be subject to revision at short intervals.

Such extra liberty to a few schools would I believe make it easier to revise the larger list of high schools and private schools, which are constantly changing in personnel but incessantly asking certificate privileges.

Such a revision ought only to be made on the basis of personal inspection, upon formal application of the principal. Some colleges charge a fee of five dollars for inspection or if a special journey be required for such a visit, the expenses of it. A report should then be made to our faculty, and approval should continue unless students notably deficient came to be recommended when the name of that school would be dropped from the list. An abstract of the work of men during Freshman year could easily be made and probably would be a fair means of investigating such matters.

It might also be desirable to require the principals of such listed schools to furnish annually the names of all teachers employed, the text-books used and the method of teaching pursued in certain branches, together with catalogues and reports; and finally to certify that the graduate in whose favor a certificate was issued had been in attendance for at least a year; or have the certificate indorsed and concurred in by the principals of schools previously attended.

At all events visitation and frequent revising of our lists would put the College in sympathetic touch with the schools of the State and perhaps keep us from running away from them.

(3) It seems certain that the slight change just made in the new schedule, which put Calculus back into Sophomore year and Analytics into Freshman year has made work more strenuous for the average student.

Men are then less mature and self-reliant and less able "to find themselves" in the face of new intellectual worlds like the Analytics and Calculus. In the second semester of Freshman year particularly there are too many new subjects. Many of the courses are

overcrowded. The surfeit and confusion interferes seriously so far as Mathematics is concerned with that part of the process of education whereby a man learns to make sure of himself. How much the distractions of College life, its irregularities of attendance and divided attention have had to do with carrying out of the new programme, I cannot say.

My last report called attention to the crowded condition of our class-rooms and their inconvenience of arrangement for supervision. Pursuant to your letter I am now having put into shape such suggestions as I am able to make in this matter, for the use of the Board of Trustees. In this connection you will, I am sure, pardon my again emphasizing the fact: that, while we do not require expensive equipment of many kinds, the regular meeting of instructors in light, well-ventilated rooms with plenty of blackboard space is a prime requisite for our work. This condition is possible of realization and must be met.

The highest efficiency on the part of the instructors can only be got by assigning such schedules to them as shall enable and require them to appear with vigor at each recitation and sensibly conduct it from start to finish.

Absolutely needful relief was given last June when the temporary instructorship in Mathematics was made permanent, but even so the work and number of hours now assigned to each instructor is more than the work assigned in Mathematics in any institution of our grade of which I have knowledge.

I am pleased to report the gift of a number of reference and text books to our library by John F. Shields, Esquire of the class of 1892. Dr. Shields was at one time a member of our staff and knows our needs along these lines. His gift is all the more acceptable on that account.

At the opening of the College year three new instructors were employed to fill places then vacant. Mr. Homer R. Higley, an Ohio State man, came to us from the East Stroudsburg Normal with an enviable reputation as a teacher and has won his place among us. Mr. F. W. Beal came to us from Colgate, highly recommended for scholarly ability and has done faithful work, and Mr. Geo. A. Whittemore, a Harvard graduate, came to us from the Foster School in Cornwall, Conn., and has been very successful and very helpful.

To my associates Professors Tudor and Leete; and Dr. Stecker and Mr. Gravatt I wish also to say a word of appreciation on the completion of another year of individual and united effort.

Finally I wish particularly to acknowledge my very great indebtedness to your wise and kindly direction and support.

Respectfully submitted,

J. M. WILLARD,
Professor of Mathematics.

May 28, 1906.

XI.—PHYSICS.

To the President:

Sir: The condition, the needs and the work of the Department of Physics are essentially the same as for the preceding one or two years. My reports for 1904 and 1905 apply to the present situation as well as anything that could now be prepared. I would respectfully resubmit these as my report for 1906, earnestly calling your attention to the matters discussed in them and hoping that provision for important changes and advances may be accomplished before the time for another report.

Respectfully submitted,

I. THORNTON OSMOND.

State College, Pa., May 16, 1906.

X.—PSYCHOLOGY AND ETHICS.

To the President:

Sir: I beg to report herewith upon the work of Psychology and Ethics for the year 1905-6.

The courses have been given as outlined in the catalogue, and although the classes continue small, the interest has been steady and gratifying. The demands, moreover, weigh no less heavily upon the conscientious teacher who instructs small sections than upon him whose numbers are large. The interest may not be so spontaneous, but a more personal and individual contact results which ought to be educative.

The laboratory apparatus for psychological study remains in the main building, in the smaller of the two rooms formerly used by the department. The room is ill adapted for anything more than rough, qualitative work, and until suitable quarters are available, we must forego entirely certain phases of psychological experiment. The suggestion of Professor Osmond in a recent report may be a feasible one, that provision for psychological laboratory and lecture rooms might be combined advantageously in the plans for a Physics Building. The conditions for experiment and the apparatus used do to a certain extent overlap, although the problems raised and sought to be answered are totally distinct. How the relief comes is not, however, so important as that it comes. The use of a room in the Library for lecture purposes has been entirely satisfactory and at no apparent inconvenience to the Library's interest.

Our needs continue as in years past. On the side of laboratory apparatus, a modest sum should be available annually, that the equipment be rendered more useful and permit of wider applications.

On the side of literature, I urge again the need of books, periodicals, studies, and psychological reports. Careful buying in the past has given us some valuable aids in the way of periodical files. But the necessities are wide. Many of these will be impossible of supply, or at least increasingly expensive as the years go by. One set of a psychological journal bought a few years ago by the department from a special appropriation would to-day cost five times the amount paid, and it would be a matter of good fortune to secure a set even under these circumstances. First, books, sources themselves; then books about books, is in no place more of a truism than in psychological fields.

Thanking you, sir, for personal inspiration and support.

Respectfully submitted,

ERWIN W. RUNKLE,
Professor of Psychology and Ethics.

May 28, 1906.

XII.—ROMANCE LANGUAGES.

To the President:

Sir: It gives me pleasure to report a successful year in my Department. The students have approached the work with more than usual zeal and enthusiasm with corresponding beneficial results. More variety than usual has been used in instruction in order to avoid the monotony and sameness which so often impede the progress possible in subjects of this nature. We have striven our utmost to make the best use of the hours assigned us and are satisfied with our efforts in most cases. We have been handicapped less than before by insufficient preparation in the fundamentals of English grammar, though the ignorance of the larger proportion of the entering class concerning the simple principles of the grammar of their own language is still a great drawback to rapid progress.

The methods we have followed this year have been similar to those of previous years. The Freshman class has finished the grammar, taking to irregular verbs the first semester, and completing it the second. In addition to this they have read about one hundred pages in the reader, and about one hundred and seventy-five duodecimo pages of fairly difficult narrative, both in the original French and in translation. The stories of Erckmann-Chatrian have been used in this connection for several years with gratifying success. Much emphasis has been put upon the pronunciation of the original, also upon composition, that the student might become familiar with the language from every viewpoint. All possible time has been given to conversation, though we feel that it has availed but little owing to lack of opportunity for practice outside of the classroom. The extra practicum period allowed in the spring session has given a chance for practical work in the line of dictation, sight-reading and composition, offering thus a variety of treatment which has greatly enhanced the interest in the subject.

As the first semester of the Sophomore year is the end of modern language study for the students in the technical courses, we have made an effort to give the work as much of the literary flavor as possible. With this end in view a story of recognized literary merit has been read and translated in class, special stress being laid upon the author's peculiarities of style and the tendencies of his time. A portion of the hour each day has been devoted to composition and word-building, that the student might be kept in touch with the foreign tongue from every side. The practicum hour this semester has been used entirely for practice in the scientific side. Reliable articles from periodicals and works on different lines of scientific research have been read and the irregularities of the syntax explained and commented upon.

The rest of the work, being with students in the general courses, has been given a distinctively literary tendency. The history of the

literature of the language has been thoroughly and carefully considered with a minute analysis of the causes underlying the great epoch-making movements of the seventeenth and nineteenth centuries. The development of the language along the lines of poetry and prose have been closely followed with particular attention paid to the successive stages in the progress of the art of drama and novel writing, two fields in which the French excel. Copious selections, illustrating the development of both species of composition, have been read in class and critically examined. An effort has been made to use only the language studied in connection with this work, translation being resorted to only when absolutely necessary. This feature has met with a hearty response from the students and has been productive of much good.

I would like to emphasize once more here the importance of an entrance requirement in modern languages. With this in force, the work now done in three semesters could be completed in two, thus leaving the sophomore year free for the studies of the course followed. If it should be thought best to keep the same time as given to the subject now, a very satisfactory course could be arranged, and the students offered something more than the dreary monotony of grammar and syntax. French is coming to be studied more and more in the preparatory schools of the State, and last fall several in the entering class had had previously one or two years of the language. This entrance requirement is becoming general in all the higher institutions of learning, the elements being relegated to the elementary schools, and State must adopt the same procedure if she would maintain her rightful place among the colleges of her rank.

The work in Spanish has been along the usual lines. Two classes have been maintained, one of four pupils, the other of twenty-five. Conscientious and consistent work has been noticeable in the case of both, and we have felt encouraged. The beginning class was larger than usual, showing that the popularity of the language has not abated. The fact that this subject is an elective and an extra, subject to grade in every study, has prevented a larger number from embracing the opportunity to pursue the course offered. The advisability of putting this language on equal footing with French and German is worth considering, owing to the part Spanish-speaking countries are playing at present in our national affairs.

It gives me pleasure again to testify to the faithfulness of my assistant, Miss Nichols. She has ably seconded every plan proposed for the betterment of the efficiency of the department. Her tirelessness and zeal have made it possible to broaden the scope of the instruction given and to use to the best advantage the time allotted to us. I would most respectfully recommend that her services be retained for the department.

We have greatly enjoyed the French papers so kindly furnished. The students are using them frequently as a means of getting hold of the living language. They will be found a useful adjunct in practicum work and will be greatly appreciated both by teachers and pupils. We are grateful also to the librarian who has made easy access possible to the foreign papers and periodicals.

Several more histories of the literatures of France and Spain would be of great help in the advanced work of the Department.

What we have now are excellent, but our reference books in the line of romance languages are far too limited in number. Several senior theses have been written in this Department and it was found difficult to provide the material necessary. At a comparatively slight expense the library could be supplied with facilities ample for all demands of this character.

I would like also to ask for a map of France and Spain. A knowledge of the locality studied is often of inestimable advantage in the understanding of the descriptions of places referred to in the books which the class may be reading. Familiarity with the topography of the country is indispensible for a student in any of the modern languages. The influence of the geography of a country upon its inhabitants and their language and customs cannot be overestimated. Probably in no country is this fact more true than in France and Spain.

In conclusion, Mr. President, I would thank you for your unfailing sympathy and help, and my colleagues for the courtesy and generosity displayed toward the work of my Department.

Very respectfully yours,

IRVING L. FOSTER,
Professor of Romance Languages.

May 28, 1906.

XIII.—SUB-FRESHMAN (PREPARATORY) CLASS.

To the President:

A brief annual report of the Sub-Freshman class is respectfully submitted.

Since I have had charge of the work but a few months the report will be short and few, if any, recommendations made.

There were forty-four (44) students in the Sub-Freshman class at the opening of the present College year. Some of these, owing to a lack of preparation or an unwillingness to work, were dropped at the close of the first semester. Four (4) others were compelled to drop out on account of sickness or duties at home. However, three of the latter expect to return for the examinations in September. They were among the best students in the class, and have, in the meantime, made arrangements to go on with the work at home under competent instructors.

At the beginning of the second semester the class received from the Freshman class six (6) additional members for full Sub-Freshman work, and four (4) for certain branches in which they were deficient.

The number in the class at present is forty-two (42), most of whom should be able to start the Freshman year with no conditions. These should be able to carry the Freshman work better than if they were prepared elsewhere because all of the instructors make the work a direct preparation for their future work here. All of them are earnest students and will be a decided addition to the next year's Freshman class.

There are three decided reasons in my opinion for the maintenance of this Department: (1) It affords a place for a student to make up deficiencies or a place to which he may be dropped if he is unable to carry the Freshman work, and thus, probably, enable him to get a college education; (2) the students from this Department should be among our best Freshmen; (3) it furnishes a nucleus of forty or more students for the Freshman class. It seems to me, therefore, that a plan should be formulated by means of which the number of students in this Department could be increased.

Very respectfully,

HOMER R. HIGLEY,

In Charge of the Sub-Freshman Class.

State College, Pa., May 8, 1906.

XIX.—REPORT OF THE TREASURER.

State College, Pa., September 4, 1906.

To the Board of Trustees of The Pennsylvania State College:

Gentlemen: The following report of the Treasurer of The Pennsylvania State College, for the period between July 1, 1905 and June 30, 1906, is respectfully submitted.

The accounts are arranged under the following titles, corresponding to the ledger headings in the College books of account.

1. The College General Account.
2. The United States Account, act of 1890.
3. The Eastern and Western Experimental Farm Interest Account.
4. State Appropriation of 1903.
5. State Appropriation of 1905.
6. The George Blight Legacy Account.
7. The McAllister Hall Account.
8. Experiment Station General Account.
9. Experiment Station U. S. Account of 1887.

THE COLLEGE GENERAL ACCOUNT.

Dr.

To cash received from Land Scrip Fund,..	$30,000 00	
To proceeds of notes discounted, ...	17,060 00	
To cash received on account of Andrew Carnegie Loan Fund, ...	1,250 00	
To cash received on account of Louise Carnegie Scholarship Fund, ...	1,250 00	
To cash received on account of John W. White Fellowship and Scholarship Fund,	850 00	
To amount received from students and all other sources, ...	103,448 48	
To balance due Treasurer, June 30, 1906,..	9,379 51	

Cr.

By amounts due Treasurer, July 1, 1905,	$4,712 49
By bills paid on account of Schwab Auditorium, ...	250 55
By bills paid on account of Carnegie Library, ...	135 00
By bills paid, Andrew Carnegie Loan Fund,	1,240 69
By bills paid, Louis Carnegie Scholarship Fund, ...	1,217 00

By bills paid John W. White Fellowship and Scholarship Fund,		811 30
By notes paid,		14,195 31
By College bills paid,		140,675 65
	$163,237 99	$163,237 99

UNITED STATES ACCOUNT, ACT OF 1890.

Dr.

To balance in hands of Treasurer, July 1, 1905,	$561 57	
To amount received from U. S. Treasurer,	25,000 00	

Cr.

By College expenses paid,		$21,653 60
By balance in hands of Treasurer, June 30, 1906,		3,907 97
	$25,561 57	$25,561 57

EASTERN AND WESTERN EXPERIMENTAL FARM INTEREST ACCOUNT.

Dr.

To amount received from State Treasurer,	$1,020 00	

Cr.

By College expenses paid to June 30, 1906,		$1,020 00
	$1,020 00	$1,020 00

STATE APPROPRIATION ACT OF 1903.

Dr.

To balance in hands of Treasurer, July 1, 1905,	$1,599 03	

Cr.

By College expenses paid,		1,598 88
By balance in hands of Treasurer, June 30, 1906,		15
	$1,599 03	$1,599 03

STATE APPROPRIATION, ACT OF 1905.

Dr.

To proceeds of notes discounted, ...	$11,327 89	
To amount received State Treasurer, ...	159,771 01	

Cr.

By notes paid, ...		$6,000 00
By College expenses paid, ...		161,104 06
By balance in hands of Treasurer, June 30, 1906, ...		3,994 84
	$171,098 90	$171,098 90

GEORGE BLIGHT LEGACY ACCOUNT

Dr.

To balance in hands of Treasurer, July 1, 1905, ...	$6,000 00	
To one-half of interest at 5 per cent. to November 5, 1905, ...	150 00	

Cr.

By balance in hands of Treasurer, June 30, 30, 1906, ...		$6,150 00
	$6,150 00	$6,150 00

THE McALLISTER HALL ACCOUNT.

Dr.

To balance in hands of Treasurer, July 1, 1905, ...	$3,499 76	
To cash deposited to balance account, ...	10	

Cr.

By bills paid on account of McAllister Hall, ...		3,499 86
	$3,499 86	$3,499 86

EXPERIMENT STATION GENERAL ACCOUNT.

Dr.

To balance in hands of Treasurer, July 1, 1905, ...	$2,818 81
To amount received for fertilizer analyses,	13,063 70
To amount received for live stock, ...	3,590 00
To amount received for seeds, plants, etc.,	596 59
To proceeds of notes discounted, ...	950 00
To amount received from all other sources,	2,318 63

Cr.

By notes paid,		$1,600 00
By Experiment Station bills paid,		19,823 84
By balance in hands of Treasurer, June 30, 1906,		1,913 89
	$23,337 73	$23,337 73

EXPERIMENT STATION, U. S. ACCOUNT, 1887.

Dr.

To balance in hands of Treasurer, July 1, 1905,	$12 50	
To amount received from U. S. Treasurer,	15,000 00	

Cr.

By experiment station bills paid,		$13,610 41
By balance in hands of Treasurer, June 30, 1906,		1,402 09
	$15,012 50	$15,012 50

Checks for this balance were drawn prior to June 30, 1906, but had not been returned to bank at time of closing this account.

SUMMARY.

COLLEGE ACCOUNTS.

Dr.

To total amount in hands of Treasurer, July 1, 1905,	$6,947 87	
To total amount received to June 30, 1906,	351,127 48	

Cr.

By total amount expended to June 30, 1906,		$353,401 90
By balance in hands of Treasurer, June 30, 1906,		4,673 45
	$358,075 35	$358,075 35

EXPERIMENT STATION ACCOUNTS.

Dr.

To total amount in hands of Treasurer, July 1, 1905,	$2,831 31	
To total amount received to June 30, 1906,	35,518 92	

Cr.

By total amount expended to June 30, 1906,		$35,034 25
By balance in hands of Treasurer, June 30, 1906,		3,315 98
	$38,350 23	$38,350 23

GRAND TOTAL.

Dr.

To total balance in hands of Treasurer, July 1, 1905,	$9,779 18	
To total amount received in year ending June 30, 1906,	386,646 40	

Cr.

By total expenditures in year ending June 30, 1906,		$388,436 15
By total balance in hands of Treasurer, June 30, 1906,		7,989 43
	$396,425 58	$396,425 58

Respectfully submitted,
JOHN HAMILTON,
Treasurer.

ANNUAL REPORT

OF

The Pennsylvania State College

FOR THE YEAR 1905-1906.

PART II.

AGRICULTURAL EXPERIMENT STATION.

Part I Contains the Reports of the Departments of Instruction.

HARRISBURG, PA.:
HARRISBURG PUBLISHING CO., STATE PRINTER,
1906.

☞ By action of the Legislature of 1905, the quota of its annual reports assigned to the Station has been reduced to 3,600 copies. This number is scarcely more than sufficient to supply those addresses to which the report is required by law to be sent and consequently it can no longer be supplied to individuals. Members of the Senate and House are assigned a limited number for distribution for which application should be made to them directly. The bulletins of the Station, as heretofore, will be mailed regularly, free of charge, to residents of the State who request it. Address, *Director of Experiment Station, State College, Centre County, Pa*

Visitors will be welcomed at all times and given every opportunity to inspect all the departments of the station.

THE PENNSYLVANIA STATE COLLEGE

AGRICULTURAL EXPERIMENT STATION.

Advisory Committee of the Board of Trustees.

THE HON. JOHN A. WOODWARD, Chairman, ... Howard.
M. E. CONARD, M. D., ... West Grove.
H. V. WHITE, Esq., ... Bloomsburg.
WILLIAM F. HILL, Esq., ... Mont Alto.
GEO. W. ATHERTON, LL. D., President of the College, ... State College.

HENRY PRENTISS ARMSBY, Ph. D., LL. D., Secretary of the Committee.

Officers and Assistants.

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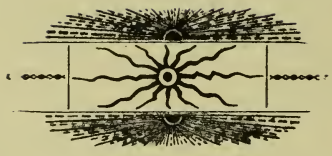
HENRY PRENTISS ARMSBY, Ph. D., LL. D., ... Director.
WM. FREAR, Ph. D., ... Vice Director and Chemist.
GEORGE C. BUTZ, M. S., ... Horticulturist.
GEORGE C. WATSON, M. S., ... Agriculturist.
THOMAS I. MAIRS, M. S., ... Animal Industry.
WILLIAM C. PATTERSON, ... Superintendent of Farm.
MISS JULIA CATHARINE GRAY, ... Secretary and Librarian.
J. AUGUST FRIES, ... First Assistant in Animal Nutrition.
M. S. McDOWELL, M. S., ... First Assistant Chemist.
J. PLUMMER PILLSBURY, ... Assistant in Horticulture.
MELVIN H. PINGREE, B. S., ... Assistant Chemist.
W. W. BRAMAN, B. S., ... } Assistants in Animal Nutrition.
ROBERT E. STALLINGS, M. A.,* ..... }
F. W. CHRISTENSEN, B. S., ... }
N. C. HAMNER, B. S., ... }
ARTHUR W. CLARK, B. S.,‡ ..... } Assistant Chemists.
WILLIARD A. SMITH, B .S.,§ ..... }
PERCY W. FLINT, B. S.,|| ..... }
J. H. PARKINS, B. S.,** ..... Assistant in Animal Nutrition.
JOHN W. WHITE, B. S.,††..... Assistant Chemist.
FRED. S. PUTNEY, B. S., ‡‡ ..... Assistant in Agriculture.
MISS E. F. JONES,§§ ..... }
MISS EVA JONES,|| || ..... } Stenographers.
MISS ALICE R. JONES,*** ..... }
MISS M. ISABEL INNES,††† ..... }
H. D. EDMISTON, ... Laboratory Assistant.

---

*To October 1, 1905.
‡To July 18, 1905.
**From October 1, 1905, to May 10, 1906.
§To November 17, 1905.
||From September 1, 1905.
††From January 1, 1906.
‡‡From June 16, 1906.
§§To September 1, 1906.
|| ||To August 12, 1905
***From August 12, 1905.
†††From September 1, 1905.

Telegraph, Post Office, Railroad and Express Station,
STATE COLLEGE, CENTRE COUNTY, PA.
Bell and United Telephones.

5—20—1906



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FINANCIAL STATEMENT, 1905-1906.

A. THE UNITED STATES APPROPRIATION FOR THE UNITED STATES FISCAL YEAR ENDING JUNE 30, 1906.

The Pennsylvania State College Agricultural Experiment Station, in account with the United States appropriation, 1906.

Dr.

To receipts from the Treasurer of the United States, as per appropriation for the year ending June 30, 1906, under act of Congress approved March 2, 1887, $15,000 00

Cr.

June 30, By Salaries,		$9,576 43	
Labor,		1,137 74	
Publications,		749 79	
Postage and stationery,		471 91	
Heat, light, water and power,		179 48	
Chemical supplies,		749 84	
Seeds, plants and sundry supplies,		22 60	
Fertilizers,		153 53	
Feeding stuffs,		944 76	
Library,		233 13	
Tools, implements and machinery,		98 30	
Scientific apparatus,		238 66	
Live stock,		72 00	
Travelling expenses,		184 13	
Contingent expenses,		40 00	
Buildings and repairs,		147 70	
		$15,000 00	$15,000 00

State College, Pa., August 29, 1906.

We, the undersigned, duly-appointed auditors of the Experiment Station accounts, do hereby certify that we have examined the books and accounts of the Agricultural Experiment Station of The Pennsylvania State College for the fiscal year ended June 30, 1906; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000 and the corresponding disbursements $15,000, for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance to be accounted for in the fiscal year beginning July 1, 1906.

M. E. CONARD,
GABRIEL HIESTER,
Auditors.

Attest:
JAMES A. BEAVER,
Custodian.

B. TOTAL RECEIPTS AND EXPENDITURES, ALL SOURCES, FOR THE YEAR ENDING JUNE 30, 1906.

Receipts.

	United States appropriation.	State appropriation.	General account.	Total.
Tobacco experiments,		$1,521 62		$1,521 62
United States appropriation,	$15,000 00			15,000 00
Fertilizer and feeding stuffs analysis,			$13,049 55	13,049 55
Farm sales,			3,106 55	3,106 55
Miscellaneous,			317 47	317 47
Expenditures over receipts,			576 46	576 46
	$15,000 00	$1,521 62	$17,050 03	$33,571 65

Expenditures.

	United States appropriation.	State appropriation.	General account.	Total.
Salaries,	$9,576 43	$174 98	$5,987 46	$15,738 87
Labor,	1,137 74	894 03	4,445 77	6,477 54
Publications,	749 79		1,237 46	1,987 25
Postage and stationery,	471 91	3 84	215 48	691 23
Heat, light, water and power,	179 48		491 30	670 78
Chemical supplies,	749 84	2 70	673 66	1,426 20
Seeds, plants and sundry supplies,	22 60	22 22		44 82
Fertilizers,	153 53	31 70	192 77	378 00
Feeding stuffs,	944 76		739 20	1,683 96
Library,	233 13		94 10	327 23
Tobacco experiments,			1 55	1 55
Tools, implements and machinery,	98 30	32 99	665 22	796 51
Furniture and fixtures,			8 10	8 10
Scientific apparatus,	238 66	44 56	528 21	811 43
Live stock,	72 00		163 80	235 80
Traveling expenses,	184 13	59 52	173 46	417 11
Contingent expense,	40 00	88 85	1,040 89	1,169 74
Buildings and repairs,	147 70	166 23	391 60	705 53
	$15,000 00	$1,521 62	$17,050 03	$33,571 65

REPORT OF THE DIRECTOR.

REPORT OF THE DIRECTOR.

To the President:

Sir: I have the honor to submit the following report upon the work of the Agricultural Experiment Station for the year 1905-06.

PERSONNEL.

With the opening of the year, the staff of the Station was enlarged by the appointment of Assistant Professor Thomas I. Mairs as head of the Station work in Animal Industry. During previous years, Professor Mairs has voluntarily assisted in the work of the Station, as mentioned in previous reports, so that his appointment was rather a recognition of work completed and in progress than an actual addition to the working force of the Station.

While there have been somewhat fewer changes among the assistants of the Station than occurred last year, they have still been more numerous than is consistent with the development of a strong and experienced force.

Mr. N. G. Miller, B. S., terminated his engagement as assistant in Agriculture on June 16, just before the close of the last fiscal year and after my previous report had been submitted. The vacancy thus created was filled by the appointment of Mr. F. W. Christensen, who during the previous year served as assistant in Animal Nutrition under appointment from the U. S. Department of Agriculture, as assistant in Agronomy and Animal Industry.

Mr. A. W. Clark, B. S., assistant chemist, resigned on July 18.

Miss Eva Jones, stenographer, resigned on August 12, the vacancy being filled by the appointment of Miss Alice R. Jones.

Miss E. F. Jones, stenographer, resigned on September 1, the vacancy being filled by the appointment of Miss M. Isabel Innes.

Mr. Percy W. Flint, B. S., was appointed assistant chemist, September 1, to fill the vacancy created by the resignation of Mr. A. W. Clark already noted.

Mr. R. E. Stallings, B. S., assistant in Animal Nutrition, resigned on October 1, the vacancy thus created being filled by the appointment of Mr. J. H. Parkins, B. S., on the same date.

Mr. W. A. Smith, B. S., assistant chemist, resigned on November 17, the vacancy thus created being filled on January 1 by the appointment of Mr. J. W. White, B. S.

Mr. J. H. Parkins, whose appointment is noted above, resigned on May 10. The vacancy thus created has not yet been filled.

In addition to the above resignations and appointments, some temporary changes have been found necessary during the year. In November, Mr. N. C. Hamner, assistant chemist, became seriously ill and was given an extended leave of absence to complete his recovery, he not returning to duty until March 23. A portion of Mr. Hamner's time had been assigned to the investigations in animal nutrition, the corresponding portion of his salary being paid by the U. S. Department of Agriculture. In order to prevent in-

terruption of this work, Mr. F. W. Christensen was transferred, January 1, to temporarily fill Mr. Hamner's place, while the vacancy occasioned by this transfer was filled by the temporary appointment of Mr. E. H. Hess, B. S., a graduate of the class of 1900, and later by the temporary appointment of Mr. F. S. Putney, B. S., the latter appointment having been continued to the present time.

WORK OF THE YEAR.

Agricultural Chemistry: Except in one particular the work of this Division has been much the same as in previous years. The exception consists in the co-operative soil tests with fertilizers which have been inaugurated on the plan described in the last annual report of the Station. This comparatively simple plan, devised by the Chemist of the Station, is intended to enable the individual farmer, at comparatively small expense, to learn something as to the main fertilizer requirements of his soil. Although this plan was first published in the spring of 1905, it met with little response. In the spring of 1906 attention was again called to the matter, early in the season, and the Station offered to supply the necessary fertilizers, weighed out and ready for application, to the first 100 applicants, of whom, however, not more than 10 should be residents of the same county. In response to this offer over 250 applications for the fertilizers were received. The sets were alloted to residents of 38 different counties of this State, and a number of other farmers who were not early enough in applying or who desired to experiment upon a larger scale arranged to make the co-operative tests with fertilizers purchased for them by the Station at their cost. It is believed that the experiments thus inaugurated, besides proving of much benefit to the experimenters and their neighbors, may be of considerable value as a preliminary study of the soils of the state and, it is hoped, may lead not only to more extensive investigations in the field, but to more fundamental and thorough investigations in the laboratory and plant house.

The investigations upon the culture and curing of tobacco, which have been carried on by this Division for a number of years, have been continued and somewhat extended with the aid of the State appropriation made by the last Legislature.

Experiments upon the growth of Sumatra wrapper leaf under shade have been continued at two localities in Lancaster county and a factory test of the commercial quality of the crop of 1904 has been made. While not conclusive, the results of the three years' work are very decidedly encouraging as regards the growth of this type of tobacco on the lighter soils of the county. Incidental to these experiments, a trial is being made of the Russian Sand Vetch as a means of renovating the light soil which had been used continuously for tobacco culture and thereby brought into bad mechanical condition. Some laboratory studies of the same soil are also under way.

A beginning has been made in a study of the influence of seed selection upon the type and form of Sumatra leaf obtained, but the work has not been continued long enough to permit of any definite report.

At the earnest request of the Lancaster County Tobacco Growers' Association, a study of the practical prevention of pole burn in

tobacco has been begun, the method of experiment being the use of artificial heat and ventilation during the critical periods of curing. The method is one requiring considerable skill and experience, and it is not surprising that the first attempt was not altogether successful. It is believed, however, that the method has sufficient promise to warrant a further trial under, if possible, closer personal supervision by a trained observer.

As in previous years, a large number of samples of milk have been analyzed by the Division in connection with tests of dairy cattle conducted under the supervision of the various breeders' associations. In addition to this, herd tests at the homes of owners have been conducted at several different times during the year, although it has been impossible to provide sufficient force to meet the numerous and increasing demands in this direction.

The routine analytical work of the Division has, as in earlier years, consumed the larger share of the time and energy of the chemist and his assistants. This routine work includes analyses of official fertilizer samples collected by the State Department of Agriculture, together with other miscellaneous work received from the Department, and the analyses made in connection with experiments carried out by other Divisions of the Station, in particular the Division of Animal Nutrition. The analysis of samples of commercial feeding stuffs collected by the State Department of Agriculture has been transferred to its own laboratory at Harrisburg, but, on the other hand, the demands upon the Division of Agricultural Chemistry have been somewhat increased by the decision of the Trustees to undertake analyses for the millers of the state of goods produced by them and required under State law to bear a guarantee of composition.

The meteorological observations have continued in charge of this Division of the Station, and the chemist has continued to serve, as in previous years, as Chairman of the Committee on Food Standards commissioned by the U. S. Secretary of Agriculture to collaborate with him in fixing standards of purity for foods.

Agriculture and Poultry: A considerable part of the work of this Division, as in previous years, has been in continuation of experiments that were initiated many years ago. The so called "general fertilizer experiments" have been conducted for twenty-four years and cover six complete rotations. The results of these experiments are each year becoming more valuable. They have been continued for a longer period than any similar tests in this country, and their average results should therefore largely eliminate accidental variations. In addition to the direct results of the experiments, the plats themselves, with a known history of nearly a quarter of a century, offer most valuable material for soil study, whenever the means of the Station permit this to be taken up.

The variety tests of farm crops continue to show a marked difference in the productiveness of the various varieties, and indicate that the yield of farm crops in the State may be very much increased by greater care in the selection of seed.

During the year, tests of soiling crops which were begun two years ago were continued in co-operation with the Division of Animal Nutrition.

The most important new work of the Division has been the initia-

tion of experimental work upon poultry, which has been assigned to this Divison partly as a matter of convenience but largely on account of Professor Watson's recognized position as an authority on this subject. Previous to this year, our equipment as regards poultry was exceedingly meagre. With the aid of the special State appropriation made by the last Legislature this state of affairs has been materially bettered. There have been erected a one-story, brick incubator building, 19 by 25 feet, two permanent poultry houses, 12 by 20 feet, and six brooder and colony houses. Additional fowls have also been purchased, and at the present time the Station is maintaining flocks representing four classes of fowls, three of which are being used for experimental purposes, namely, the American the Mediterranean and the Asiatic classes. The increase in equipment has not been available long enough to permit the attainment of any experimental results, but it is expected that interesting and valuable work will be done during the coming year.

Animal Industry: As noted above, the feeding of soiling crops in continuation of experiments conducted for the past three years has been in charge of this Division in co-operation with the Division of Agriculture. Certain crops previously experimented with have been discarded, and it is believed that a fairly satisfactory rotation of soiling crops for this section of the State has been secured.

The preliminary observations on the protein supply of the dairy herd, which were partially reported a year ago, were continued to January 1, 1906, or a full calendar year. While the results do not warrant any radical conclusion, they indicate that the supply of protein in excess of that required for maintenance plus that contained in the milk is of less importance than was formerly believed, and may easily be too expensive for the best economical results.

During the winter, a feeding experiment was made to test the value of "alfalfa meal," which has been recommended as a substitute for wheat bran. At the price asked for the former, it is more expensive than bran, and in this experiment showed no advantage over the latter. Alfalfa is, of course, an exceedingly valuable feed, especially for dairy cows, but the farmers of Pennsylvania should raise it themselves and get the advantage of its fertilizing effect upon the soil, rather than purchase it in the form of alfalfa meal at relatively high prices. With a plentiful supply of home grown alfalfa, clover, or other leguminous crops, a suitable ration can easily be made up from the more common farm grains or by-products which are generally cheaper relatively than bran. This is especially true in view of our own experimental results and those of others which seem to show that the proteid demands of dairy cattle have been over estimated.

The experiments upon the value of shelter for fattening steers have been continued, with results corroborating those of former years, namely, that temperature does not materially affect the gain, but that dry quarters are of very great importance.

The invention of what seems to be a practicable milking machine is a matter of much importance to the owners of large herds. Arrangements have accordingly been made with D. H. Burrell & Co., Little Falls, N. Y., to place one of their milking machines at the Station for test and it is expected that it will be installed within a short time.

I regret to state that tuberculosis has again appeared in the Station herd, which has been free from it since 1892. A test, under the direction of Dr. Leonard Pearson, State Veterinarian, during the month of March resulted in the condemnation and slaughter of 15 animals. As the herd was free from tuberculosis when last tested, and as no animals had been bought except a bull, which was purchased after a tuberculin test by a competent veterinarian, and which came from a farm said never to have had a case of tuberculosis, the appearance of the disease here was quite unexpected. During the summer of 1902 some of the heifers and one cow were taken to a pasture in the mountains. Here they ran for some months with about two hundred head of other cattle. It is possible that the disease was contracted by some of these from the strange cattle in this pasture and then transmitted to others in the Station herd. The barns have been thoroughly disinfected under the direction of the Live Stock Sanitary Board and it is thought that no further development of the disease will take place.

Animal Nutrition: The Division of Animal Nutrition has continued to enjoy the co-operation of the Bureau of Animal Industry of the U. S. Department of Agriculture. During the year the experiment outlined in my previous report upon the influence of age and individuality upon the rate of gain has been continued. The past season's work has but recently been completed, and it has not been possible to finish the computation of the results; consequently definite report upon the progress of the experiments must be deferred for the present. A bulletin upon the available energy of clover hay, supplementary to the one published as Bulletin No. 74 of the Bureau of Animal Industry, is nearly ready for publication. Some minor improvements in the apparatus have also been made during the year.

Horticulture: The available funds of the Station have not permitted of any extension of the strictly horticultural work beyond the testing of varieties which has been continued for a number of years past. Several other lines of work not strictly horticultural have, however, been taken up.

The popular interest excited by the advertisement of the so-called "nitro cultures," i. e., cultures of the bacteria which enable leguminous crops to assimilate the free nitrogen of the air, led to the inauguration of a series of tests of the cultures as offered commercially to the trade. The trials included pot experiments in the green house in sterilized sand and field cultures. Since neither method of trial showed any particular advantage arising from the use of the commercial cultures, we feel justified in warning farmers against expending any considerable amount of money in their purchase. At the same time, however, it should be noted that this conclusion does not in any way modify the fact of the importance of these bacteria in the soil, nor does it show that artificial inoculation of the soil is impracticable, but simply that the particular form of culture which has been offered is not effective.

Experiments have been inaugurated in co-operation with celery growers in the vicinity of Wellsboro, Tioga county, with reference to the control of the celery rust which has caused much loss in that region. Similar co-operative experiments on the control of the black rot of the grape in Erie county in 1903 have proved eminently

satisfactory to the growers. A recent visit to that section by the Horticulturist showed a general use of spraying, in accordance with the Station's recommendations. A representative of the Bureau of Plant Industry of the U. S. Department of Agriculture is now planning some investigations in that region on the life history of the black rot fungus, and the Station is keeping in touch with the work although not actually co-operating to any considerable extent.

At farmers' institutes and other like organizations during the winter, farmers of the State were invited to send specimens of their seeds to the Station for investigation as to vitality and purity. Some 46 samples have been received, their examination being assigned to the Horticulturist. In the same line, samples of seed corn have recently been collected from various parts of the State by the Agriculturist, and are now being tested by the Horticulturist as to germinative power.

The Horticulturist of the Station has assisted during the months of December and January at farmers' institutes in the State, and during the month of August acted as nursery inspector for the State Department of Agriculture.

Secretary's Office: The work of the Secretary's office includes the care of the Station accounts, the general charge of the correspondence, the mailing of publications and the care of the library and reading room.

The correspondence of the Station has shown a decided increase during the year, and notwithstanding the entire change in the stenographic force, the work has been carried on in a very satisfactory manner.

The publications of the Station have included the annual report for the year 1904-05, which is now in press, and six bulletins as follows:

No. 72. Experiments in Growing Sumatra Tobacco under Shelter Tent, 1903.

No. 73. Distillers' Dried Grains vs. Cottonseed Meal as a Source of Protein.

No. 74. Methods of Steer Feeding.

No. 75. Forage and Soiling Experiments, 1904.

No. 76. Variety Tests of Wheat, Oats and Potatoes.

No. 77. Small Fruits in 1905.

A number of press bulletins have also been issued. As noted in my last report, the quota of annual reports assigned to the Station has been reduced from 10,000 to 3,600 copies, so that after supplying the newspapers of the State and kindred institutions in other states, both of which must be done under the provisions of the Hatch act, practically no reports are available for distribution to individuals. The mailing list of the Station has increased by the addition of more than one thousand new names, the total being over 17,000. During the latter part of the year the mailing room was transferred from the cellar of the Station building to the old dairy building. With a few changes this building was put in fair condition to accommodate this work and renders the care of the mailing much more easy.

The library of the Station has increased during the year chiefly

by the accumulation of periodicals and of the bulletins and reports of other stations. Our general policy has been to expend the larger portion of the fund assigned to the library in the purchase of technical journals of standard character, so that the Station now possesses files of the more important agricultural, chemical, botanical and physiological journals of this and other countries, which are of great and increasing value in research. Additional shelf room is seriously needed for the proper accommodation of the library.

As noted in my last report, the Legislature of 1905 made an appropriation of $2,500 for the erection of an implement shed and poultry houses, and one of $5,000 per year for the general maintenance of the Station. With the former appropriation an implement shed 45 by 80 feet has been erected and also the incubator and poultry houses mentioned in connection with the poultry work. Of the appropriation for maintenance, $1,500, was assigned to investigations upon the culture and curing of tobacco, as noted in connection with the work of the Division of Agricultural Chemistry. Pending the reorganization of the entire agricultural work of the College, no further appropriations from this fund have been made with the exception of a small amount for experiments with poultry. Accordingly, there has been no very marked extension of the Station work during the year past, while a correspondingly large portion of this fund will be available for the coming year.

Respectfully submitted,

HENRY PRENTISS ARMSBY,

Director.

REPORTS OF DIVISIONS.

DIVISION OF AGRICULTURAL CHEMISTRY.

WILLIAM FEAR, Ph. D., Vice-Director and Chemist.

MILTON S. McDOWELL, M. S., ... First Assistant Chemist.
MELVIN H. PINGREE, B. S., ...
N. C. HAMNER, B. S., ...
ARTHUR W. CLARK, B. S., ... Assistant Chemists.*
WILLIARD A. SMITH, B. S., ...
PERCY W. FLINT, B. S., ...
JNO. W. WHITE, B. S., ...
HARRY D. EDMISTON, ... Laboratory Assistant.

REPORT OF THE CHEMIST.

To the Director:

Sir: I have the honor to present the following report upon the work of the Division of Agricultural Chemistry for the year 1905-6. Before taking up the routine work of the laboratory, I will note several special features of the year's work:

SOIL TEST.

In the last annual report of this Division, the writer referred to the large number of requests constantly received for the chemical examinations of soils of the State with reference to their present fertilizer deficiencies, and described briefly a simple plan for a soil test by use of fertilizers of the three types chiefly offered on the Pennsylvania market, namely, dissolved rock, rock and potash, and complete fertilizers. It is hoped that several valuable results may be attained by the organization of a series of such co-operative experiments. The individual farmer will be assisted in the solution of his fertilizer problems, his neighbors having similar farms will be benefited in like manner; the conduct of such experiments will have an educational value, leading the way to the use of the experimental method for the solution of other problems; the data obtained will constitute a fund of information valuable in a systematic survey of the soils of the State. Not least of the advantages resulting from co-operative work in other states, has been the resulting promotion of cordial relations between the Station and the producer by which the resources of the Station are made more useful to the farmers of the State.

For one reason or another, the proposals of the Station for the season of 1905 met with little response. Since these proposals contemplated the purchase by the farmer of the requisite fertilizers

*This list includes all chemists who were connected with the Station during any part of the year.

either in a ready-mixed condition or in the form of single ingredients for home-mixing, it was thought that the uncertain difficulties and expense of such purchase might have deterred many from co-operating who would otherwise have gladly engaged in the undertaking.

To obviate this difficulty, therefore, when attention was again called to the plan for such experiments, the Station offered to supply to the first one hundred applicants, of whom, however, not more than ten should be residents of the same county, the requisite fertilizers, providing the applicants would agree to carry out the experiments in accordance with the Station's directions.

The result of this offer has been very gratifying. There were over two hundred and fifty applicants for the fertilizers offered. The sets were allotted to residents of thirty-eight different counties of the State. In addition, a few farmers who were not early enough in applying or who desired to experiment upon larger areas, have arranged to make the co-operative tests with fertilizers purchased at their own charge.

The following is a list of those who have undertaken these soil tests:

CO-OPERATIVE SOIL TEST.

Allegheny County:

Dawson, Robert, Tarentum, Pa.
Schmidt, W. J., Gibsonia, Pa.
*Phillips, Prof. F. C., Allegheny, Pa.

Armstrong County:

Bush, Clyde T., Freeport, Pa.
Enty, George, Templeton, Pa.
Loomis, J. K., Putneyville, Pa.

Bedford County:

McDaniel, Albert, Everett, Pa.

Berks County:

Bashore, C. R., Bethel, Pa.
Berger, O. F., Hamburg, Pa.
Dunkel, Charles, Temple, Pa.
Plank, H. E., Joanna, Pa.

Bradford County:

Clark, John H., Rome, Pa.
Curren, John, Gillett, Pa.
Foster, Wm. M., Canton, Pa.
Taylor, W. B., Standing Stone, Pa.
Whipple, Elmer H., Skinner's Eddy, Pa.

Bucks County:

Betts, Jacob C., New Hope, Pa.
Freed, Harvey M., Quakertown, Pa.

Butler County:

Vandivort, W. W., Callery, Pa.

Cambria County:

McElheny, Gust, Ashville, Pa.
Sheehan, E. A., Ashville, Pa.

Cameron County:

Johnson, Wm. R., Emporium, Pa.

Carbon County:

Eroh, R. A., Weatherly, Pa.
Kressley, Daniel, Lehighton, Pa.
Sloat, H. H., Rockport, Pa.

Clarion County:

Cowan, W. J., Holden, Pa.
Denslinger, Lea, Shippensville, Pa.
Hamilton, J. H., New Bethlehem, Pa.
Polliard, E. E., New Bethlehem, Pa.
Tippery, Henry, Callensburg, Pa.

Clearfield County:

Ashenfelter, Elijah, DuBois, Pa.
Kopp, W. J., Karthaus, Pa.
Smith, M. T., Penfield, Pa.
Stott, Parley, Olanta, Mitchell's Station, Pa.
Wall, T. L., Grampian, Pa.

Columbia County:

Beaver, Wm. G., Catawissa, Pa.
Kshinka, R. G. F., Berwick, Pa.

Crawford County:

Anderson, Frank, Geneva, Pa.
Borrell, H., Meadville, Pa.
Boylan, B. L., Cochranton, Pa.
Gee, Leroy E., Linesville, Pa.
Lawrence, Ed. F., Conneautville, Pa.
Lawrence, S. B., Conneautville, Pa.
McCurdy, J. M., Hartstown, Pa.
Waring, H. E., Waring, Pa.
Williams, J. E., Cochranton, Pa.

Dauphin County:

Steinruck, A. W., Middletown, Pa.

Erie County:

*Hamilton, Wm. Erie, Pa.
Lee, W. W., Waterford, Pa.
Mayhne, John, Union City, Pa.
Young, Burton R., Girard, Pa.

Fayette County:

Baker, J. H., Cheat Haven, Pa.
Boyd, Carroll C., Connellsville, Pa.

Huntingdon County:

McNerling, J. L., Hubelsville, Pa.
Mierly, K. W., Mapleton Depot, Pa.

Jefferson County:

Brian, Charles, Brockwayville, Pa.

Lackawanna County:
Smith, Harry, Dalton, Pa.

Lancaster County:
Bricker, John R., Lititz, Pa.
Herr, Adam B., Mountville, Pa.
Hess, Enos H., Windom, Pa.
Reinhold, S. G., Ephrata, Pa.

Lehigh County:
Backenstoe, M. J., Emaus, Pa.

Luzerne County:
Garrison, Henry, Beach Haven, Pa.

Lycoming County:
Warner, H. E., Pensdale, Pa.
White, Philo W., Cogan Valley, Pa.

McKean County:
*Ingalsby, Maynard, Custer City, Pa.

Mercer County:
Barbor, J. C., Grove City, Pa.
Greenlee, A. B., Sandy Lake, Pa.
McCalmont, A. M., Sandy Lake, Pa.
Merry, W. P., Sharpsville, Pa.

Monroe County:
Blakeslee, F. P., Blakeslee, Pa.
Bush, M. D., Kunkletown, Pa.

Montgomery County:
Jeffries, Leslie, Bridgeport, Pa.
Rosenberger, Art., Telford, Pa.
Warner, John, Royersford, Pa.
Zeigler, James H., Red Hill, Pa.

Northampton County:
Ettinger, Alfred H., Mt. Bethel, Pa.
Kressler, Wm. H., Mt. Bethel, Pa.

Perry County:
McMillen, L. R., Loysville, Pa.
Shade, F. M., Markelsville, Pa.

Potter County:
Martin, R. F., Wharton, Pa.

Schuylkill County:
Heine, J. E., Orwigsburg, Pa.

Somerset County:
*Ott, Daniel, Winber, Pa.

Susquehanna County:

Brewster, D. T., Montrose, Pa.
Chamberlain, H. S., Gibson, Pa.
Gere, C. E., Brooklyn, Pa.
Lowe, A. C., Elk Lake, Pa.
Omar, Olin, Susquehanna, Pa.
Reader, W. E., Uniondale, Pa.
States, Eugene J., Nicholson, Pa.
Stone, D. E., Thompson, Pa.

Tioga County:

Beach, N. M., Mansfield, Pa.
Davis, Mrs. Lucy A., Westfield, Pa.
Fick, H. I., Morris, Pa.
Tipple, A. L., Wellsboro, Pa.
Rolison, P. V., Westfield, Pa.

Venango County:

Weaver, G. L., Polk, Pa.

Westmoreland County:

Barnhart, Frank D., R. D. No. 4, Mt. Pleasant, Pa.
Ekin, Robert W., McKeesport, Pa.
Elliott, W. B., R. D. No. 2, Mt. Pleasant, Pa.
Hunter, Wm. A., R. D. No. 2, Mt. Pleasant, Pa.
Monroe, W. J., Greensburg, Pa.
Overly, George, Laurelville, Pa.
Shaffer, Geo. M., Alice, Pa.

Wyoming County:

Frear, Edgar C., Lake Winola, Pa.
Keeney, M. C., Laceyville, Pa.
Place, L. T., Meshoppen, Pa.

Note.—The names to which the (*) is prefixed are those parties who have arranged to co-operate and bear the entire cost of the test.

Permit me to note, in this connection, that several years ago the Bureau of Soils, U. S. Department of Agriculture, devised a simple method of pot experimentation, requiring less than a month for the conduct of a series of tests of the fertilizer requirements of a single soil. The appliances required by this method are simple and inexpensive. Last year, the method was very carefully checked by tests upon soils at the Ohio and Rhode Island Experiment Stations, where field fertilizer experiments have been in progress for many years. The results of these pot tests of less than a month's duration were in excellent accord with those of the field trials lasting for some years. On the basis of these experiments, the fitness of the simple wire pot method for preliminary soil studies appears to be quite well established. In point of cost, a soil test by this method is much less expensive than a thorough chemical analysis, and its indications with respect to present fertilizer needs are doubtless more completly trustworthy. By its use, many soil problems may be solved without the need for complete check by a long series of field experiments on individual soils or by complex chemical analyses.

Since this Station has an extensive series of fertilizer experiments that have been in progress longer than any similar experiments in America, a comparative series of tests by the new method would be of much scientific interest. Furthermore, since in Pennsylvania soils exhibit a great variety with respect to geological origin, texture, systems of rotation, and time under cultivation; and since upwards of $5,000,000 is annually expended for commercial fertilizers alone, the extension of the soil work in my charge so as to include systematic studies of Pennsylvania soils by this and related methods, would not only increase the Station's usefulness, but, judging from my correspondence with Pennsylvania farmers, would meet with live appreciation.

TOBACCO INVESTIGATIONS.

During 1905, the experiments in the *growing of Sumatra tobacco under shelter* were continued on the farm of Mr. Risser, near Milton Grove, and on the farm of Mr. H. D. Burkholder, near Cocalico, both on the "Penn Sandy Loam" soil of Lancaster county. The results thus far obtained are sufficiently promising to make further tests desirable.

Cultural experiments have also been made in certain *filler varieties* of tobacco, both on the sandy loam at Milton Grove, and on the heavier limestone near Marietta.

No suitable factory test of the Sumatra wrapper having been successfully arranged, and the leaf product having found no buyer—owing, it was stated, to the small quantity of the leaf available and its subdivision into many small lots of various sizes and colors—the writer spent the month of August in Lancaster county and was successful in arranging several series of *factory tests* of the 1904 leaf, the results of which are elsewhere reported in detail, but which may be summarized by the statement that the leaf was found to be of large wrapping capacity and good color, but to be slightly wanting in gum, life and toughness.

The attempt to grow tobacco for three years in succession on the sandy loam soil at Milton Grove without the use of an intervening green manuring crop or of a fertilizer rich in humus-producing substances, led to the development, early in the growing season of 1905, of a peculiar tough, compact condition of the soil which greatly retarded the early development of the tobacco plants and for a time interfered with their satisfactory cultivation. Samples of the soil were taken for a laboratory study to determine whether a deficiency of humus was the probable cause of this condition. Furthermore, after the harvesting of the 1905 crop, *Russian sand vetch*, which Mr. A. D. Shamel had reported as an excellent green manure crop for the Sumatra tobacco of Connecticut, was sown to test its value for the purpose on the Lancaster county sandy soils.

Owing to the wide variety in the characters of the plants grown from Sumatra seed obtained from Connecticut, a series of *seed selections* was instituted, having for its purpose the development of a Lancaster county type of this leaf. It is a well recognized fact that the tobacco leaf responds quickly and pronouncedly to a change in soil and climate. They are strongly influential upon the first year's crop from seed brought from other localities—although not sufficient to obscure at once the principal varietal characters of the

parent plant. The two alternatives appear, of returning each year to the use of seed imported from a favorable locality, or of yielding somewhat to the environing influences and striving by selection to retain the characters chiefly desirable in a tobacco variety, while the other characters are allowed to respond with less check to the local tendencies. The latter alternative has been adopted for the most part in the planning of these seed selections.

One other line of investigation was begun at the earnest request of the Lancaster County Tobacco Growers' Society, viz., *a study of the prevention of pole-burn.* The method adopted has, in one form or another, been used with more or less success in other localities. It is intended to repress pole-burn by the prevention or removal of the atmospheric conditions of high heat and high humidity which favor the development of pole-burn. The regulation of these conditions was attempted by the use of furnace-heat and ventilation at the critical periods.

By arrangement with Mr. H. M. Engle, near Mt. Joy, Pa., his tobacco barn was equipped with a furnace, one section of the large barn being devoted to the heating test, while other sections were ventilated as usual and thus served for comparison. The successful application of the method requires considerable experience, and it is not surprising that the results of the first experiment have been unsatisfactory. It is hoped that this work may be continued.

The work of soil study, seed selection, preparation of equipment for pole-burn experiment and factory tests of wrapper leaf was conducted under the writer's personal supervision. Mr. M. L. Greider has continued to represent very efficiently the Lancaster County Tobacco Growers' Society as the local superintendent of experiments. The work at Milton Grove was conducted by Mr. Frank B. Grosh, as foreman; that at Cocalico, by Mr. B. B. Burkholder, as foreman; while Mr. H. M. Engle carried out the details of the pole-burn experiment.

METEOROLOGICAL OBSERVATIONS.

The charge of the detailed observations and tabulations of weather data devolved upon Mr. N. C. Hamner until his absence on account of illness, when the duty was assigned to Mr. F. W. Christensen. The reports made during the year have been (a) Monthly reports of pressure, temperature, precipitation, cloudiness, humidity and miscellaneous phenomena for the Section Director of the U. S. Bureau at Philadelphia; (b) Monthly reports of total precipitation to the U. S. Weather Bureau, Washington, D. C.; (c) A phenological report prepared by the co-operation of the Horticultural Division, for the U. S. Weather Bureau, Philadelphia; (d) Weekly weather and crop reports to the Section Director, U. S. Weather Bureau, Philadelphia; (e) Weekly summaries of temperature and precipitation for the local press; (f) Weekly reports on depth of snow to the U. S. Weather Observer, Pittsburg. Although the Weather Bureau has greatly reduced the number of Stations to which telegraphic predictions are distributed, the writer was enabled, through the courtesy of the Section Director, to have them continued for this Station. The daily predictions have been made known by the display of flags from the tower of the main building.

ANALYTICAL EXAMINATIONS MADE.

The samples received for analysis since my last report are as follows:

Farm, barn and creamery samples and subsamples,	1,167
Official fertilizer samples,	2,216
Miscellaneous samples,	753
	4,136

The miscellaneous samples have been of the following description:

Feeding-stuffs,	67
Fertilizers,	24
Lime and limestones,	10
Other rocks and minerals,	9
Soils,	15
Milks and butters,	583
Unclassified,	45
	753

Official Fertilizer Samples: There were received during 1905 from the official sampling agents of the State Department of Agriculture 2,216 fertilizer samples. After the combination of duplicate samples to form composites for analysis, the number of samples submitted to examination was 983. Their analysis involved the making of 10,350 determinations.

Other Work for the State Department of Agriculture: The Department having established a laboratory at Harrisburg for the examination of commercial cattle foods, the official samples of this character are no longer examined by my Division. The Station has, however, made check analyses at the request of the Department and has examined a number of insecticide preparations for the State Economic Zoologist.

Work for the State Superintendent of Printing: In the summer of 1905, a series of 24 book papers were examined, for the State Superintendent of Printing, to determine their composition and physical qualities.

HERD TESTS.

During the year, the Division has continued to make check analyses in connection with tests conducted under the supervision of various breeding associations for the advanced registration of dairy cattle. Samples have been received from herds belonging to the following owners:

Ayrshire Herds:

Mr. Geo. H. McFadden, Bryn Mawr, Pa.
Mr. John R. Valentine, Bryn Mawr, Pa.

Guernsey Herds:

Mr. Clement A. Griscom, Haverford, Pa.
Hollingsworth Bros., Landenburg, Pa.
Mr. T. E. Hyde, Bloomsburg, Pa.
Mr. J. P. Welsh, Bloomsburg, Pa.

Holstein-Friesian Herd:

Mr. Geo. M. Carpenter, Wilkes-Barre, Pa.

By special arrangement, stall tests were conducted by Mr. W. A. Smith in September, 1905, on the herd of Mr. Geo. M. Carpenter, Wilkes-Barre, Pa., and in March, 1906, by Mr. P. W. Flint, on the herds of Messrs. McFadden and Valentine, at Bryn Mawr, Pa. The requests for stall tests are more numerous than the Station is at present able to meet. The care of the milk samples examined at the Station and of the records is in Mr. Pingree's hands. The total number of samples examined in connection with this milk work during the current year has been 607, involving 1,174 determinations.

OTHER WORK OF THE DIVISION.

As for some years past, there has been maintained a close relation between this Division and that of Animal Nutrition. During the intervals between fertilizer control seasons, a large portion of the time of my assistants has been given to analytical and other work connected with the respiration calorimeter experiments. On the other hand, Messrs Parkins and Faber of that Division have assisted in work upon calorimeter samples that has hitherto been chiefly performed by my own assistants. It still remains true that, with the current demands of control work, that of other Divisions of the Station, and of miscellaneous samples received from without, my force is insufficient to permit me to devote the time of a single assistant continuously to investigations naturally belonging to my own Division.

At the request of the State Millers' Association, arrangement was made by the Station whereby millers' samples of cattle feeds of their own manufacture might be analyzed at the millers' cost. The number of samples received for analysis under this arrangement, however, was small.

As for some years past, the writer has continued his service on the Committee on Food Standards, commissioned by the Secretary of Agriculture to collaborate with him in fixing standards of purity for foods.

ORGANIZATION.

The duties performed by M. S. McDowell, M. S., first assistant chemist, and M. H. Pingree, B. S., have been the same as last year, and are fully described in the report for that year.

N. C. Hamner, B. S., was obliged, owing to illness, to drop his work in November, 1905, and was unable to resume his place in the laboratory until March of the current year. During the fertilizer season, he has been charged with the determination of water—soluble and citrate-insoluble phosphoric acid. During the summer and early fall of 1905, he determined the heats of combustion of samples related to the work of the Division of Animal Nutrition.

Since his resumption of duties, this spring, he has been engaged in the analysis of soils representing Lancaster county tobacco areas.

Arthur W. Clark, B. S., resigned in July, 1905, to accept a position in the laboratory of the New York State Agricultural Experiment Station at Geneva, N. Y.

Willard A. Smith, B. S., was engaged during the summer of 1905, in the analysis of samples relating to the work of the Division of Animal Nutrition, numerous miscellaneous samples, and in the analysis of soils related to the tobacco experiments.

P. W. Flint, B. S. (University of Charleston, S. C.), was appointed an assistant in September, 1905, has been charged with the determination of nitrogen in fertilizer and general Station samples. He has also assisted Mr. Pingree in the analysis of milks and in the determination of ether extract in cattle foods, feces, etc. In the month of March, he conducted a milking test on the Ayrshire herds of Messrs. McFadden and Valentine, Bryn Mawr, Penna.

J. W. White, B. S. (A. and M. College, Raleigh, N. C.), who has had some experience as a commercial chemist since his graduation, was appointed an assistant in January of the current year. He has been engaged in the examination of miscellaneous samples, in the determination of crude fiber and ash in samples from the Division of Animal Nutrition, and is at present occupied in the determination of total phosphoric acid in fertilizer control samples.

H. D. Edmiston has continued his services as laboratory assistant. In connection with fertilizer control analyses, he has made the determinations of moisture and of fineness of bone, and has assisted the chemist making determinations of soluble and reverted phosphoric acid. Since the resignation of Mr. R. E. Stallings, whom he assisted in the determinations of carbon and hydrogen, these determinations have been placed in his charge.

In closing, permit me again to express my appreciation of your cordial support and loyal aid of my assistants.

Very respectfully,

WILLIAM FREAR,
Chemist.

EXPERIMENTS IN GROWING SUMATRA TOBACCO UNDER SHELTER TENT, 1904.

BY WILLIAM FREAR.

SUMMARY.

In general, the experiments of 1904 demonstrate that it is possible to grow from seed of the Sumatra strain upon sheltered land of the light sandy type stretching across northern Lancaster county, wrapper leaf that approaches in quality the average imported Sumatra, with respect both to color, luster, fineness of vein, wrapping capacity and burn.

Further, that the yield obtainable per acre is such in relation to the cost of production as to leave a very large margin between the cost per pound to the grower and the present prices paid by the local manufacturer for Sumatra wrapper, either imported or Florida grown.

These are the results, however of but a single season's test on this light soil. The results, do not afford a safe basis of judgment with respect to the yield and quality of shelter-grown tobacco obtainable during the average season in this locality.

The experiments made in 1902 and 1903, on the farm of Dr. Alexander near Marietta, developed the fact that the leaf there produced was chiefly of a dark color and had a little less elasticity than the normal imported Sumatra leaf. These qualities were possibly due to the character of the soil. Although this soil is classed in the soil survey as a gravelly loam, the field used for the experiment really exhibited little or no gravel, but consisted of fine loam to the depth of three feet or more. While plant roots distributed freely through the soil, it was found, in the interspaces between the rows of tobacco plants, that the soil tended to pack under foot and to puddle so as to retain pools of moisture after the rain.

The leaf obtained in 1903 at Milton Grove, on the much more open sandy soil that stretches across the northern portion of Lancaster county, was of better elasticity and of a much lighter color than that obtained in the experiments at Marietta. Tobacco growers of Lancaster, Lititz and Ephrata reported that the very finest wrappers produced from the Havana and the Seed Leaf varieties of tobacco were grown on this red sandy formation. It was therefore decided to abandon the Marietta site and to continue the experiments on the lighter soils above mentioned. In April, 1904, the writer visited a number of districts on the red sandy soil, which has been classed in the Bureau of Soils Survey as "Penn Sandy Loam," and selected a tract on the farm of Mr. H. D. Burkholder, near Cocalico, situated about eight miles north of Ephrata and between

four and five miles northeast of Denver, on the Philadelphia and Reading road. The remoteness of the location from the railroad was a disadvantage, offset by the excellent reputation of the wrapper tobacco grown on Mr. Burkholder's farm.

It was also arranged to continue the experiments, on a smaller scale, at Milton Grove.

While the plans for the conduct of the experiment were prepared by the writer, they were carried out under the supervision of Mr. M. L. Greider as the representative of the Lancaster County Tobacco Growers' Association, Mr. B. B. Burkholder acting as local foreman at the Cocalico Station.

THE EXPERIMENTS AT COCALICO.

The site selected for the experiment was a gently inclined upland, quite well supplied with humus, but without any evidence of clay or silt subsoil within a depth of twelve to fourteen inches. At the foot of the slope below this upland, silt accumulations, forming a rather compact subsoil, were found at a depth of six to eight inches. The area covered by the shelter embraced, in all, about fifty square rods.

THE SHELTER.

The type of construction adopted at Marietta was followed also in this shelter, that is, it was composed of a framework of posts overlaid in one direction by scantling, which was also laid in parallel lines across the short end rows of posts; and, of heavy guy wires laid across the former rows of scantling at right angles thereto and immediately over the rows of posts. The scantling was supported by braces nailed on two sides of the post. These braces were possibly not necessary to make the structure sufficiently strong and added somewhat to the cost of construction. The light wires were stretched in lines parallel to the rows of scantling to serve as the immediate support of the covering cloth. All the wires were attached to stout stakes driven into the ground at a distance of one-half rod outward from the rows of posts. The cloth used was manufactured by J. H. Lane & Co., of New York City and was of the Ariel weave.

The cost of the shelter may be itemized as follows:

Tenting cloth, 308 yards at 21½ cents,	$66 22
Fifty-one posts, 12 feet long, four inches in diameter at the top, peeled chestnut, at 10 cents,	5 10
Sixty stakes, 4 feet by 4 inches by 4 inches, at 5 cents,	2 40
Hemlock scantling, 2x4x16½, 1,111 feet at $20 per M,	22 22
Base boards, 511 feet,	10 66
Galvanized wire No. 12, 73 pounds,	2 57
Galvanized wire No. 9, 41½ pounds,	1 25
Nails, staples, hinges, etc.,	1 52
Labor, 308½ hours, at about 15 cents,	48 47
Total,	$160 41

The estimate of the Bureau of Soils, for the cost of construction of a shelter an acre in area, was, in 1902, $315.04, allotting $288.04 to materials and $27.00 to labor. In that estimate, the prices of posts and stakes were 18 cents and 5 cents respectively. The total amount of scantling required was 2,156 feet and of base boards, 924 feet; so that the total cost of the lumber for the acre was estimated at $86.35 as contrasted with $40.38 for our much smaller area. The estimated cost of tenting cloth was 17 1-3 cents a yard. The greatest difference is found, however, in the labor, the actual cost of the Cocalico shelter being nearly twice as great as that given in the Bureau of Soils estimate for a whole acre. The entire area of the Cocalico shelter was four by nine rods, or thirty-six rods in the square, or fifty square rods if the area covered by the sloping sides be also included. The area available for cultivation was practically one-fourth of an acre; since at the narrow ends of the shelter, the headlands could not be planted and under the sloping sides, running lengthwise, the additional rows of plants did not much more than compensate for the loss of space due to the posts.

In making the above estimate for the Cocalico shelter, all items of freight and hauling were omitted. The time expended by a number of those assisting in the construction included, in some instances, the hours engaged in travel to and from the site of the shelter tent. It is probable, under present prices of labor and materials, that even with the simplest construction and the cheapest materials, the cost for tenting an acre of land will exceed $400, and also that with the simple structures found sufficient in other localities, the cost need probably not far exceed that figure.

PREPARATION OF THE SOIL.

The land used for the experiment had previously been cropped with grain and had been given substantial dressings of stable manure. Samples of the soil were taken in 1904 and submitted to mechanical and chemical analyses, which will be reported in another connection. The land was plowed on June 6th and thoroughly cultivated, the last harrowing being given on the 15th of June. The fertilizer employed was a homemade mixture, composed of the following ingredients:

Cotton seed meal,	450 lbs.
Carbonate of potash,	67 lbs.
Dissolved South Carolina rock,	233 lbs.
Total,	750

This mixture had been estimated as sufficient for one-third of an acre, but really was applied to an area a little greater than one-fourth of an acre. The actual cost of the fertilizer used, not including the haulage, was $16.88, equivalent to about $50 per acre. It was distributed broadcast and thoroughly harrowed in on June 15th just before the planting.

THE PLANTS.

The plants were grown at Mount Joy under the supervision of Mr. Greider, from seed purchased from a Connecticut grower and

said by him to represent the best type of Sumatra leaf produced in that locality. The beds were prepared early in April and had developed sufficiently to be covered with cloth on April 23. The tobacco was planted at Cocalico on June 15.

THE WEATHER.

The general character of the season, as compared with that of other years, may be fairly judged from the records of the U. S. Observatory at Harrisburg, the nearest post of observation for which a long series of records are available. The Harrisburg records from April to September, 1904, show the following average monthly temperatures and departures of the same from normal; total rainfall by months and departures from the normal, and days during which 1-100 of an inch of rain fell:

1904.	Temperature (Deg. Fahr.)		Precipitation.		Days with .01 inch or more of rain.
	Monthly mean.	Departure from normal.	Inches.	Departure from normal.	
April,	46.7	—3.4	2.07	—1.39	12
May,	63.8	+3.6	3.54	—1.25	12
June,	69.1	—1.4	3.99	—0.27	14
July,	73.2	+0.3	4.76	+0.51	16
August,	70.6	—1.5	2.95	—1.56	8
September,	65.4	+1.0	1.69	—2.38	10

These records show that the actual growing season for the tobacco crop, from June and through August, was, on the average, somewhat cooler than usual, but that the rainfall was considerably below normal, not only during the growing season but during the spring months.

The rainfall observations, taken at Cocalico from the time of planting to the maturing of the crop, that is, from June 16 to September 15, gave the following results:

June 16-30,	1.88 inches.
July,	3.87 inches.
August,	5.29 inches.
September 1-15,	2.82 inches.

These figures vary comparatively little from those obtained at Harrisburg. Exceptionally heavy rains were observed July 12, 1.22 inches; August 10, 1.91 inches and August 20, 1.44 inches. The total number of days of rainfall was June 15-30, 8 days; July, 14 days; August, 9 days and September 1-15, 5 days. Despite the deficiency of rainfall, the weather was more cloudy than usual. Mr. Greider, speaking of the character of the season, reported on August 17, a fine growth of tobacco; on September 15, that the weather had not been very favorable for ripening under canvas, the 9th, 14th and 15th having been rainy. He reported on October 5, that, in general, the tobacco had been well ripened before it had been harvested. It

was estimated that during this season nearly 50 per cent. of the Lancaster county tobacco crop had been injured by hail and frost, but neither the Cocalico nor the Milton Grove crops experienced injury from these causes.

CULTIVATION.

The crop at Cocalico was hoed and harrowed on June 27, July 6 and July 18. Some of it was sufficiently developed for topping by August 1, and additional topping was given on the 8th and 19th of August. The tobacco was suckered on August 15th and 27th and September 5th. The thin web and vein of Sumatra leaves make them especially liable to have one part of the leaf turned over the other part by the action of the wind. This condition, if allowed to continue, results in making the protected portion of the leaves lighter in color than the exposed part and tends to lower the value of the sweated leaf. A number of hours were spent on August 3d and 6th in turning the leaves which had been considerably affected by the wind.

HARVESTING.

The lower leaves were ready for priming on September 5th; the second lot, those next in position, on the 13th; the third priming was given September 21st, and the last September 26th. The number of days of growth, from the time of planting up to that of the first priming, was 82 days; and to that of the last priming, 103 days. The total degrees of temperature, which is the sum of the mean daily temperatures during the period under consideration, was, to the time of the first priming, 5,900 degrees, on the basis of the Harrisburg observations, and to the time of the last priming, 7,227 degrees.

THE COST OF RAISING THE CROP.

A careful record of the time alloted to the several cultural operations was kept. The cost of labor was, for man and team, 30 cents per hour; for men employed in cultivation, and men and women in harvesting, 15 cents per hour, and for young girls engaged in stringing leaves about 12½ cents per hour. The following is a summary of the labor records for this crop:

Cost of seed, raising and pulling plants,	$5 24
Plowing, harrowing and applying fertilizer,	3 30
Planting, 15½ hours,	3 27
Subsequent harrowing,	1 00
Hoeing and weeding, 32 hours,	4 80
Topping and suckering, 60 hours,	9 00
Turning leaves, 5 hours,	75
Harvesting:	
Priming, 125½ hours,	13 34
Hauling plants and shipping,	6 49
Stringing leaves, 162 hours,	19 35
Hanging the tobacco, 67½ hours,	8 57
Taking down and casing the cured leaf, 34½ hours,	5 18
Total,	$80 29

To these items of cost, the data enable us to make the following additions:

Fertilizer,	$16 53
Putting in the cover crop,	2 35
Sorting leaf before sweating, to remove trash,	36 08
One-tenth of the cost of the frame,	8 29
One-half of the cost of the canvas,	33 11
Cost of putting on canvas,	7 20
Cost of removing the canvas,	3 45
Total,	$107 01

Making the cost of the leaf ready for sweating, exclusive of the items of rent for land and curing shed, of the interest on the shelter and attendance during curing, $186.30.

As has been remarked, in reporting the earlier experiments, the expense of operations under conditions of public experiment, are far greater than found necessary in the conduct of a private business. The remoteness of the location has increased the cost; since some of the employes were carried to and from their work and were paid for the entire time spent in traveling, as well as for the time spent directly upon the work of construction and cultivation. Since the number of hours has been given, which were devoted to the several items of labor, it is hoped that the foregoing statement may be of value to private growers in estimating the probable cost of production under their own conditions.

CURING AND PREPARATION OF TOBACCO FOR SWEATING.

The leaf, harvested by priming, that is, by the removal of the leaves from the growing stalk in the order of ripening of the several leaves, was hung upon Snow laths in the curing shed and cured without the aid of artificial heat. The tobacco cured uniformly to a fine light color. When thoroughly cured, it was, during a period of moist weather, taken down, packed and shipped to Mount Joy, where the crop was carefully assorted for the removal of trash and was tied into hands, preparatory to the sweat. The entire weight of the cured leaf, including trash, was not reported.

EXPERIMENT AT MILTON GROVE.

The arrangements were made with Mr. M. Risser for the use, by the Experiment Station, of a small shelter he had used in 1903. The Station this year undertook the entire management of the experiments and paid a stipulated rental for the land and curing shed. The area under shelter was somewhat less than one-sixth of an acre. The land, which had had no cover crop during the preceding winter, was thoroughly cultivated early in the spring, and, just before planting, was fertilized with 500 pounds of a commercial fertilizer rich in organic nitrogen, potash (in the form of sulphate) and acidulated bone. The area was planted on June the 9th and 14th; it was cultivated on the 29th of July, and during July was hoed on the 1st, 14th, 16th, 28th and 30th, and was topped and suckered on July 27th and August 11th and 13th. The leaf was

Tobacco Grown by State Tobacco Experimental Station at Milton Grove.
Sumatra Under Cover, 1904.

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ready for priming on the following dates, September 1st, 2d, 7th, 12th, 17th and 19th, the harvesting being finished on the 21st. The tobacco was cured in the same manner as at Cocalico, the curing progressing to a satisfactory conclusion. The tobacco was taken down December 27th and 28th and hauled to Mount Joy where it was assorted, like the Cocalico crop, preparatory to sweating.

In the case of both crops, the leaves were harvested in a riper condition than those on 1902 and 1903 at Marietta and, consequently, exhibit much less of the undesirable green tints which characterize those earlier crops and which is an undesirable quality in much of the shade grown Sumatra leaf from Florida.

Owing to the fact that no foreman was employed to look after the Milton Grove shelter experiments, it was necessary to send workmen from Mount Joy and neighboring towns to the tract to conduct the operations from time to time, the expense of the experiments being thus so greatly increased as to make the items of cost no safe guide for the private grower. The summary of the labor sheets is therefore omitted from these experiments.

THE SWEAT.

As in preceding years, the cured leaf was shipped to Connecticut to be bulk sweated and assorted, in order that these particulars of the preparation might be conducted by workmen thoroughly familiar with the handling of leaves of this type. These operations were performed at the Indian Head Plantations, Tariffville, Connecticut, under the supervision of Mr. J. B. Stewart, of the U. S. Bureau of Soils, whose services were given through the courtesy of Professor Milton Whitney, the chief of that Bureau.

The several lots of tobacco sent for sweating were distinguished by the kind of tape used in tying the hands and especial care was taken to preserve the identity of the several materials while they were being sweated and assorted.

The temperatures during the bulk sweating, and the dates on which the bulks were turned, are given below:

January 24,	64 degrees F.
January 25,	74 degrees.
January 26,	86 degrees.
January 27,	96 degrees.
January 28, turned,	100 degrees.*
January 29,	84 degrees.
January 30,	94 degrees.
January 31,	102 degrees.
February 1, turned,	110 degrees.*
February 2,	86 degrees.
February 3,	94 degrees.
February 4, turned,	103 degrees.*
February 5,	80 degrees.
February 6,	92 degrees.
February 7,	99 degrees.
February 8,	106 degrees.
February 9, turned,	112 degrees.*
February 10,	86 degrees.

*Bulk turned.

February 11,	96 degrees.
February 12,	104 degrees.
February 13,	103 degrees.
February 14,	100 degrees.
February 15,	98 degrees.

On February 15, the company began to size and assort the crop, so no further record was kept; the temperature at no time during the process of fermentation was allowed to go over 112 degrees F.

In turning the bulk, pains were taken to see that the portions central at one time, should, at a later period, occupy the outer parts of the bulk, so that all the leaves might in turn be exposed to the most favorable conditions for the sweat.

The tobaccoes were, owing to the small quantities submitted, as sorted only as to color and quality, but not as to size of leaf. The results of the assorting, both in pounds and percentages of the total weight of the sweated leaf, are given in the following table, which includes some data for Sumatra leaves grown outside the shelter.

The total weight of leaf submitted for sweating was 418 pounds, the weight of the leaf after assorting and finishing sweating was 409 pounds. Evidently, the assorting of the leaf prior to its shipment to Connecticut had been conducted with sufficient care to remove all the trash, so that such comparatively worthless leaves, which made up 20 per cent. of the 1903 crop, did not enter into the assorted wrapper.

With reference to grades: The leaf was divided into two classes, wrapper and seconds. The Marietta crops of 1902 and 1903 showed 43 per cent. and 41 per cent., respectively, of second quality leaf, while the Cocalico crop of 1904 showed but 22 per cent. and that of Milton Grove about 35 per cent. With reference to the results of assorting as to color: The present Cocalico crop shows a larger proportion of the "light" and "dark" grades and less of the medium than was reported for the Marietta crops. A comparison of the sweated leaf indicates, however, that the assorting, with respect to tint, is relative rather than absolute; since the Marietta leaf classed as "light," corresponded very closely in tint to some of the Milton Grove and Cocalico that was classed as "dark."

The luster of the Cocalico and Milton Grove leaves was little, if at all, inferior to that of the average imported Sumatra wrapper used in the Lancaster county cigar factories; although in no case was it as excellent as that exhibited by the best Sumatra wrapper.

YIELD.

As the foregoing table shows, the entire weight of the sweated leaf obtained at Cocalico was 227 pounds. Estimating the area under cultivation as one-fourth of an acre, this would correspond to 908 pounds, of which 708 pounds were of first quality wrapper. The yield at Milton Grove was 109 pounds. The area was not measured exactly, so that no estimate is given for the yield per acre.

It may be noted, that the yield of trash-free sweated leaf, obtained at Marietta during 1902 and 1903, was at the rate of 1,092 and 993 pounds, respectively, per acre, of which 625 and 541 pounds was select wrapper. So that, while the entire weight of trash-free leaf

obtained from an acre of the Cocalico soil was less than the yield from the same area at Marietta, the weight of first quality leaf obtained at the former place was the greater.

COST PER POUND OF SWEATED LEAF.

On the preceding page, the entire cost of the Cocalico crop, excluding the rent of the land and curing shed and several minor items, was $187.30. This, for a crop of 227 pounds of sweated leaf, is equivalent to 82 cents per pound. To this amount must be added the cost of the bulk sweating and the assorting. In actual practice, these operations would probably cost between 10 cents and 15 cents per pound, according to the care with which the operation is conducted and the number of sorts into which the crop is divided, making the outside cost of the leaf range from 92 cents to 97 cents per pound.

In comparison with these figures, the prices now paid for wrapper leaf, Philadelphia markets, may be noted, viz., $3.50 to $5.00 for imported Sumatra, according to quality, and $2.50 per pound for Florida leaf of the Sumatra type. On the other hand, it should be remembered that at the present time many growers in Florida are getting no more than 60 cents for the cured leaf, shelter grown.

Compare with these figures the following: In the report on Tobacco Culture, in the Tenth Census, for Lancaster county, are presented estimates for the elements of cost entering into the total expenditure for the tobacco crop as ordinarily grown. I have recomputed these figures with the following results:

	Cents per pound.
Culture,	.825
Harvesting,	.345
Taking down and stripping,	.918
Cost of cultivation, harvesting and stripping,	2.088

The entire cost of the crop was rated at about 7½ cents per pound. At the time when these estimates were made, labor cost only $1.00 per day, and man and team $2.00 per day; at the present time, these items amount to fully 50 per cent. more.

MANUFACTURING TESTS.

For reasons mentioned in my last report, it has been found impossible to sell the wrapper leaf grown in these experiments, the reasons being especially, the difficulty of forming a fair judgment of the real quality of the various grades of leaf making up a single bale; and, second, the large loss which must follow the use of a leaf that is possibly of an inferior quality for wrapping a high class filler, which forms by far the largest factor of cost in a cigar. The writer succeeded, however, in making arrangements for tests, by two manufacturers, of select representative lots of the 1904 Cocalico crop. The first of these tests was made by the Everybody's Cigar Company of Lancaster, Pa., through the courtesy of its treasurer.

Mr. Frank Trout, the foreman of the factory, Mr. Zeller, assuming direct charge of the experiments and himself making the weighings involved and preparing the leaf for cigar maker's use.

The cigars were made by different makers and the tests represented the economy of the leaf for the making of both hand made cigars and molded cigars, that is, cigars which, after the binder has been put on, are forced into a mold and held there for sometime until their shape is quite thoroughly set. Cigars thus molded can be more quickly covered and are supposed to require a smaller amount of wrapper, thus making the prices more economical than that of hand making throughout. Cigars of this type usually receive somewhat less care in the finishing and this fact alone may account for an important part of the differences in cost.

The record of the test was kept upon blanks, furnished by the Station, and attached to each sample of leaf submitted for trial. The records of the tests, together with the notes as to quality, are as follows:

MANUFACTURER'S SHEET.

	1904. Sumatra (Cocalico). 15-inch leaf. Light-Medium Color.	1904. Sumatra (Cocalico). 22-inch leaf. Medium Color.	1904. Sumatra (Cocalico). Medium.	1904. Cocalico Sumatra. 22-inch leaf. Light-Medium Color.	1904. Cocalico Sumatra. 15-inch leaf. Light to Medium.
Stripping Record.					
Wt. before stripping (oz.), ...	16	16	16	14	17.5
Wt. of stem (oz.), ...	3	3.5	3	3	3
Wt. of strip (oz.), ...	13	12.5	13	11	14.5
Per cent. stem, ...	18.75	21.9	18.75	21.43	17.14
Cigar Maker's Record.					
Wt. of strip (oz.), ...	13	12.5	13	11	14.5
Wt. of waste cuttings (oz.), ...	7½	5.0	7	4.5	7.5
Wt. of wrapper used, ...	5½	7.0	6	6.5	7.0
Per cent. waste, ...	57.7	40.0	53.9	40.9	51.7
Cigars wrapped, ...			Mold cigar, ...	Mold cigar, ...	Mold cigar.
Quality, ...	Hand-made Perfecto, ..	Hand-made, straight, ..	Combination filler, ...	Combination filler, ...	
Binder, ...	Connecticut seed leaf, ..	Connecticut seed leaf, ..	Zimmer's Spanish, ...	Zimmer's Spanish, ...	Zimmer's Spanish.
Size, cigar (in.), ...	4⅜	4½	4⅜	4¾	4⅜
Number wrapped, ...	576	583	450	405	611
Number of leaf, ...	576	583	450	463	559
Notes on quality, ...		Makers usually reported that leaf is a little too tender, not quite elastic enough, and dries a little brittle.			

Before commenting upon these results, the data obtained by Mr. A. W. Zook, a well known cigar maker of Lancaster, Pa., in testing the lot of 1904 Cocalico Sumatra are given:

Manufacturer's Sheet.

	1904 Cocalico Sumatra.
Stripping Record.	
Weight before stripping (oz.),	25½
Weight of stem (oz.),	6.25
Weight of strip (oz.),	19
Per cent. stem,	24.5
Cigarmaker's Record.	
Weight of strip (oz.),	19
Weight of waste cuttings (oz.),	2.5
Weight of wrapper used,	16.5
Per cent. waste,	13.2
Cigars Wrapped.	
Quality,	Hand-made.
Binder.	
Size, cigar (in.),	4¼
Medium wrapped,	811
Medium of leaf,	509

Notes on quality.—Has very good yield, but dries brittle, not quite enough gum.

With reference to the covering quality of the Cocalico leaf: These experiments show that the yield of stem is quite low, the proportion being greater in the case of the larger leaves than in that of the smaller leaves. The records of the amount of waste in the first lot of tests show, however, that a larger proportion of the 22 inch leaf is useful than of the leaf 15 inches in length, from 25 per cent. to approximately 58 per cent. of the strips being wasted in case of the 15 inch Sumatra, from 40 per cent. to 41 per cent. in case of the larger leaves. When, however, we compare the number of cigars that can be wrapped by a pound of the leaf, we find, in case of the hand-made cigars, little difference between the 15 inch and the 22 inch leaves, owing probably to the greater thinness of the former; while in the case of the molded cigars, the 15 inch leaf shows a great superiority in covering power per pound of leaf. The fact that different cigar makers were engaged in these experiments, renders an exact comparison of the yields from the different sorts of leaves difficult, because the skill of the makers is doubtless a variable quality. On the other hand, the fact that four or five different makers were engaged in the test, shows what results the average workman is likely to obtain from the leaf. The very small percentage of waste reported by Mr. Zook, when coupled with the fact that he covered a small number of hand-made cigars with the leaf he used, gives rise to the question as to the correctness of the report of the waste cuttings.

The yield of this Pennsylvania grown Sumatra leaf, as compared with that from the average imported Sumatra, may be judged from the statement that a pound of the latter commonly yields wrappers for from 520 to 540 cigars, hand-made.

TESTS OF WRAPPER QUALITY.

The final test of the value of a wrapper tobacco is not obtained until its quality is demonstrated by the use of the cigar into whose make-up it enters. In addition to the qualities of luster, color and thinness of vein which please the eye of the buyer, it is important to note the resistance of the wrapper to wear such as a cigar meets in handling and when carried in the pocket, and also the burning quality of the wrapper. A good wrapper should have sufficient elasticity to stretch closely to the body of the cigar during the making, and as the cigar dries should have sufficient toughness to resist the breaking tendencies due to handling and pocket wear. Finally, it should burn without unfavorably affecting the flavor due to the filler and binder, should burn at about the same rate as the other parts of the cigar, should burn uniformly so that the cigar may not become uneven at the burning tip, and should be as free as possible from char; for with the latter not only is the appearance injured, but there is likely to be a development of undesirable flavors.

A number of observers have examined the cigars wrapped with this tobacco. Professor M. L. Whitney, Chief of the Bureau of Soils, U. S. Department of Agriculture, in charge of the Tobacco Investigations of the U. S. Government, made the following comments:

"I have tested your tobacco of the 1904 crop, shade grown, and have no fault to find with the burn, taste and color, but I fancy the leaf is a little too thin, as it appears to me there might be some danger of breaking after the cigar has seasoned out."

A number of the cured cigars were tested by F. Trout, Mr. Zeller and the writer. Those with the thin Connecticut binder smoked straight with but few exceptions. Where the heavy Spanish binder was used there was a greater tendency to burn unevenly, and there was also a greater tendency to char in the latter case; the charring being but slight where the Connecticut binder was used. In general, the ring of char in the latter case was from one-sixteenth to one-thirty-second of an inch in width. Later when the cigars had somewhat seasoned, Mr. Trout placed some of them with critical customers who had been using cigars containing the same filler and binder but made up with the imported Sumatra wrapper. The customers were not informed of the substitution of the test cigars for the ordinary brand which had been, prior to that time, always made of wrapper tobacco selected with extreme care with respect to uniformity of burn. He reports that in a few cases the customers inquired what change had been made in the tobacco used, stating that some of the cigars did not burn quite as evenly as before. Mr. Trout reported that he had himself smoked quite a large number of these cigars and found that, in general, they burned quite satisfactorily but that an occasional cigar burned unevenly.

On the other hand, Mr. Zook, who sold over 800 cigars covered

with the Cocalico Sumatra wrapper to his regular customers, reports that he had not a single instance of complaint, and that his sole criticism was that the tobacco did not have quite enough gum and therefore became a little brittle on drying out. The writer has made a number of tests of the cigars manufactured by the Everybody's Cigar Company with the following results as to evenness of burn:

Hand-made Perfecto: A. Five cigars very dry, smoked straight except where wrapper loosened, as it did in two cases. B. Cigars well cured and dry. Ten tests, eight cigars smoked straight, one started uneven but straightened, and another became uneven after being allowed to chill during the smoking. Cigars well cured and cased before smoking all burned straight, five tests. The very dry cigars showed some tendency to breaking of the wrapper when the mouth tip of the cigar was bitten off, and in two cases the wrapper curled loose from the binder. In all the other cases there was no breaking of the wrapper. In one instance there was the slight charring earlier noted.

Hand-made Straight, Connecticut Binder: A. Dry, smoked straight in five tests. B. Dry, two straight, one crooked at first but straight later. C. Fifteen tests, cased. Several started crooked but with a single exception straightened, the rest straight throughout. No trouble was experienced in the breaking of the wrapper in these tests, although some of the cigars were carried in a pocket case for several days, in comparison with high-grade Sumatra wrapped cigars some of which were injured by pocket wear. The charring was slight in each case.

Mold cigars with Zimmer's Spanish binder. Lot 5. Cigars well cured. Seven tests, five straight, one uneven but later straight and one uneven throughout. B. Eleven tests with cased cigars, ten burned straight, one uneven. All these cigars charred like the two lots earlier mentioned, the char being in no case bad. There was no difficulty due to the brittleness of the tobacco.

These results indicate that the 1904 Sumatra possesses superior qualities as a wrapper tobacco. That it is little if at all inferior to the average imported Sumatra leaf in its burn, and that while it is a little tender this difficulty is not so serious as to destroy its usefulness for commercial purposes.

THE INFLUENCE OF NITROGENOUS, PHOSPHATIC AND POTASSIC FERTILIZERS UPON THE PERCENTAGE OF NITROGEN AND MINERAL CONSTITUENTS OF THE OAT PLANT.

BY M. H. PINGREE.

The effect of various fertilizer ingredients upon the growth of crops has been the subject of much investigation. In this country, as well as in Europe, many areas have been divided into plots receiving varying amounts of different kinds and combinations of plant nutrients to be tested as to their relative efficiency for crop production.

In a great majority of the so-called fertilizer experiments the comparison has been made solely with regard to the crop yield. In other cases, the influence of fertilizers upon crop quality, both physical and chemical, has been the subject of experimentation. For instance, some investigators have studied the influence of different kinds of plant food upon the crop, while others have confined their observations to their influence upon the quantity of phosphates contained by the plant. Again such men as Professor J. Koenig have examined the ash of oat plants grown on soils previously treated with different ingredients of plant food, paying particular attention to the ratios existing between some of the constituents of the plant ash, hoping to find in these ratios, some clue to the soil deficiencies.

As may be seen by reference to the report of The Pennsylvania State College for 1901-2, this Station has, for a quarter of a century, conducted experiments upon the effects of various systems of manuring upon the crops of an ordinary four-course rotation. To these experiments, 144 plats, each of one-eighth acre area, have been devoted. The soil is characterized as a limestone clay loam and is well supplied naturally with potash.

To determine in what respects the several fertilizer constituents have affected the composition of the plants grown under such different treatments, a special study was undertaken of the composition of the oat crops grown, in 1904, upon several typical plats. The nitrogenous and ash constituents of the crops were particularly considered.

THE FERTILIZER TREATMENTS.

The rotation above mentioned consisted of the sequence of corn, oats, wheat and mixed timothy and clover.

The characters and amounts of the fertilizers, which were applied to the corn and wheat in the rotation, are stated in the following table.

Table I—Showing Fertilizers Applied Alternate Years to Corn and Wheat.

Plot No.	Kind of Fertilizer.	Pounds of fertilizer per acre.	No. of Pounds of Plant Food per Acre.		
			Nitrogen.	Phosphoric acid (P_2O_5).	Potash (K_2O).
1	Unfertilized,	.....	.....	.....	.....
2	Dried blood,	200	24	.....	.....
3	Dissolved bone black,	300	.....	48	.....
4	Muriate of potash,	200	.....	.....	100
10	Dried blood,	400	48	.....	.....
	Dissolved bone black,	300	.....	48	.....
	Muriate of potash,	200	.....	.....	100

CROP YIELDS.

The weights of grain (including the seed with its husk) and straw and chaff obtained from the several plats in 1904, are shown by the barn records as they appear in Table II.

*Table II.—Showing the Yield of the Several Plats.**

	Grain per acre.	Straw and chaff per acre.	Total yield per acre.	Proportion of grain. Per cent.	Proportion of straw and chaff. Per cent.
	Lbs.	Lbs.	Lbs.		
1. (Unfertilized plat),	880	1,440	2,320	37.9	62.1
2. (Nitrogen plat),	884	1,476	2,360	37.5	62.5
3. (Phosphoric acid plat),	1,148	1,812	2,960	38.8	61.2
4. (Potash plat),	912	1,448	2,360	38.6	61.4
10. (Complete fertilizer plat),	1,304	2,416	3,720	35.1	64.9

These figures indicate that nitrogen and potash alone applied to the preceding corn produced but trifling gains by their residual effects upon the oats; whereas phosphoric acid singly and the complete fertilizer, containing all three constituents, produced gains of approximately 25 per cent. and 60 per cent. over the yields given by the unfertilized land.

Selection of Samples: At the time of harvesting samples of the desired size were drawn from the swathe and stored in a dry room until they were thoroughly air-dry. The kernels, both the perfect

*Calculated from the yield from the one-eighth acre plats.

and the imperfect (light) ones, including the closely adherent husks, were carefully separated from each sample and the percentages of both the grain and residual substance, consisting of straw and chaff, were determined in terms of the total dry material.

The percentage proportions of grain and straw (including the loose chaff) are stated in Table III. On comparing the results in Table II, a great disparity in the percentages of grain appears. This is partially explained by the fact that, in the threshing process, many of the lighter grains are carried away with the straw; whereas, in the hand separation, they are grouped with the heavy grain.

Methods of Analysis: The official methods as given in Bulletin 46 of the Bureau of Chemistry, of the U. S. Department of Agriculture, were employed, except as otherwise noted.

In the preparation of the ash, the material was first charred over a low flame, then extracted with water, using, in case of the grains, a little acetic acid in addition. The residual mass was ignited in a very large platinum dish over an ordinary Bunsen burner to a white or grayish ash practically free from carbon, the extracted substance being then added, evaporated to dryness and ignited gently at low heat to destroy any carbonaceous matter contained in the extracted portion. The resulting ash was preserved for analysis in tightly stoppered bottles.

Table III.—Showing the Composition of the Water-Free Substance.

Treatment Alternate Years for 23 Years.	Pounds per acre.	Grain.	Straw and chaff.		Ash.	Total nitrogen.	Total protein (N x 6.25)	Albuminoid nitrogen.	Albumen (Alb. N x 6.25).	Nitrogen in albuminoid form.
		Per Cent.	Per Cent.		Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Nothing,		46.32	53.62	Grain,	3.30	2.13	13.32	1.88	11.75	.....
				Straw and chaff,	6.24	1.05	6.56	.77	4.81	.....
				Whole plant,*	4.87	1.55	9.69	1.28	8.00	82.56
Dried blood,	200	52.10	47.90	Grain,	3.43	2.15	13.44	1.96	12.25	.....
				Straw and chaff,	5.69	1.17	7.31	.86	5.38	.....
				Whole plant,	4.51	1.68	10.50	1.43	8.94	85.14
Dissolved bone black,	300	44.68	55.32	Grain,	3.62	1.75	10.94	1.49	9.31	.....
				Straw and chaff,	6.04	.92	5.75	.73	4.56	.....
				Whole plant,	4.96	1.29	8.06	1.07	6.69	83.00
Muriate of potash,	200	48.09	51.91	Grain,	3.35	2.09	13.06	1.86	11.63	.....
				Straw and chaff,	6.38	.96	6.00	.75	4.69	.....
				Whole plant,	4.92	1.50	9.38	1.28	8.00	85.29
Dried blood,	400	.....	.....	Grain,	3.68	1.89	11.81	1.70	10.63	.....
Dissolved bone black,	300	37.70	62.30	Straw and chaff,	5.33	.78	4.88	.63	3.94	.....
Muriate of potash,	200	.....	.....	Whole plant,	5.02	1.20	7.50	1.03	6.44	85.87

*Roots not included.

The results in Table II were obtained from closely agreeing duplicate determinations.

Considering the relation of ash to total dry substance: It is clear that with the mineral fertilizers, when they were associated with nitrogen, there was a larger absorption of ash materials from the soil per unit weight of crop produced than in the case where the land had been cropped for years without any manurial treatment whatever; and that, on the contrary, where the dried blood was used alone, there was a larger production of crop per unit of ash taken up than with any other treatment. Except in the case last named, the differences were, however, slight.

Considering the ratio of nitrogen to dry matter: Where nitrogen was applied alone, a larger amount was taken up, per unit of dry matter formed, than in any other case; the proportion was distinctly less in the crop from the unfertilized plat; still lower where potash alone was used; while the proportion of nitrogen was greatly depressed in the cases where phosphoric acid was used, even in that in which a complete fertilizer was applied. In other words, it may be said that, in this soil, the phosphoric acid promoted the highest economy in the use of nitrogen for the production of the organic substances of the oats crop.

There were but slight differences in the state of combination of the nitrogen in the several cases. Rather curiously, there was a smaller proportion of non-albuminoid nitrogen where nitrogen was applied as a fertilizer, with or without phosphoric acid, than where no nitrogen was applied—except in the case of the potash manuring. The differences in composition are not sufficiently pronounced, however, to suggest important differences in physiological activity under the several systems of fertilizing compared.

COMPOSITION OF ASH.

Owing to the scarcity of material available, it was necessary to limit the analytical operations upon the ash to a single determination of each constituent. The analytical work was performed, however, with unusual care. The results of these analyses are stated in Table IV.

Table IV.—Showing the Composition of the Ash.

	Grains.					Straw and Chaff.				
	Plat No. 1.	Plat No. 2.	Plat No. 3.	Plat No. 4.	Plat No. 10.	Plat No. 1.	Plat No. 2.	Plat No. 3.	Plat No. 4.	Plat No. 10.
	(Per Cent.)	(Per Cent.)	(Per Cent.)	(Per Cent.)	(Per Cent.)	(Per Cent.)	(Per Cent.)	(Per Cent.)	(Per Cent.)	(Per Cent.)
Acid insoluble,	46.74	43.43	41.26	40.24	38.25	41.15	39.93	40.87	31.94	25.66
Potash (K_2O),	17.81	17.59	18.41	19.90	18.14	25.02	23.14	22.01	37.88	37.08
Soda (Na_2O),	1.16	2.32	.92	1.89	.97	.63	2.18	.86	.78	1.51
Magnesia (MgO),	6.88	7.72	7.94	7.44	7.41	3.93	4.25	4.09	3.00	4.69
Lime (CaO),	4.59	5.07	5.98	6.90	6.19	6.64	9.47	7.94	6.39	7.39
Phosphoric acid (P_2O_5),	17.55	18.68	21.36	18.87	22.19	3.24	3.74	5.69	3.03	5.55
Sulphuric acid (SO_3),	3.58	3.18	2.73	3.27	2.72	4.70	6.32	3.95	3.77	3.56
Ferris oxide (Fe_2O_3),	2.28	2.15	1.49	1.49	3.85	1.59	1.88	1.69	2.00	1.78
Chlorine (Cl),	Trace.	Undetermined.	.25	.63	.25	.30	.10	.10	7.30	3.75
	100.59	100.14	100.41	100.63	99.97	87.20	91.01	87.20	96.09	90.97
Less oxygen equivalent to chlorine,	.00	.00	.06	.14	.06	.07	.02	.02	1.65	.85
	100.59	100.14	100.35	100.49	99.91	87.13	90.99	87.18	94.44	90.12
Carbonic acid (CO_2) (undetermined),	None.	None.	None.	Trace.	None.	*12.87	*9.01	*12.82	*5.56	*9.88
Total,	100.59	100.14	100.35	100.49	99.91	100.00	100.00	100.00	100.00	100.00

*Qualitative tests showed large amounts of carbonic acid.

The figures in Table IV were used as the basis of further computations. They will be considered, for the present, with respect to a few points only:

(a) Where muriate of potash was applied alone, there was a large increase in the proportion of potash appearing in the ash of the straw, and a very distinct increase in that of the grain; where the muriate formed part of the complete fertilizer, the increase of potash in the ash of the straw was as pronounced as where the muriate was applied alone, but the elevation of chloric less pronounced; while, in the case of the grain ash, the muriate was less influential upon composition than other constituents.

(b) Where the dissolved phosphate was applied, the proportion of phosphoric acid in the ash of both grain and straw was pronouncedly increased; the influence of the associated sulfuric acid is not, however, reflected in any distinct elevation of the percentages of this constituent in the ashes of the crops treated with the phosphate. Nor is the lime present in these ashes in so large proportion as it is in the ashes of crops otherwise treated.

(c) The major portion of the mineral matters in dissolved boneblack consists of calcium sulfate. It might be supposed that the lime and sulfuric acid in the ash would exhibit some change of pro portion where the phosphate was applied. No direct influence is reflected, however, in the composition of the ash of either the grain or the straw.

(d) The amount of silica in the several ashes, shows a marked relative decrease of this constituent where potash and complete fertilizer were used; the maximum percentage of silica appearing in the ash from the unmanured crop.

RELATION OF CONSTITUENTS TO DRY MATTER FORMED.

In Tables V-VIII the relation is shown of the several ash constituents and nitrogen to dry matter formed.

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Table V.—Showing the Number of Grams of Nitrogen and Mineral Constituents in 1000 Grams of Water-Free Substance.

Plat No.		Nitrogen.	Acid in soluble material.	Potash (K_2O).	Soda (Na_2O).	Lime (CaO).	Magnesia (MgO).	Ferris oxide (Fe_2O_3).	Phosphoric acid (P_2O_5).	Sulphuric acid (SO_3).	Chlorine (Cl).
		Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1. (Unfertilized plat),	Grain,	21.3	15.42	5.87	.38	1.51	2.27	.75	5.79	1.18	Trace.
	Straw and chaff,	10.5	25.68	15.61	.39	4.14	2.45	.99	2.02	2.93	.19
	Whole plant,*	15.5	20.91	11.09	.39	2.92	1.37	.88	3.76	2.12	.10
2. (Nitrogen plat),	Grain,	21.5	14.90	6.03	.80	1.74	2.65	.74	6.41	1.09	Undetermined.
	Straw and chaff,	11.7	22.72	13.17	1.24	5.39	2.42	1.07	2.13	3.60	.06
	Whole plant,	16.8	18.64	9.45	1.01	3.49	2.54	.90	4.36	2.29	.....
3. (Phosphoric acid plat),	Grain,	17.5	14.93	6.66	.36	2.17	2.87	.54	7.73	.99	.09
	Straw and chaff,	9.2	24.69	13.29	.52	4.80	2.47	1.02	3.44	2.39	.06
	Whole plant,	12.9	20.33	10.33	.45	3.62	2.65	.81	5.36	1.76	.07
4. (Potash plat),	Grain,	20.9	13.48	6.67	.63	2.31	2.49	.50	6.32	1.10	.21
	Straw and chaff,	9.6	20.38	24.17	.50	4.08	1.91	1.28	1.93	2.41	4.66
	Whole plant,	15.0	17.06	15.75	.56	3.23	2.19	.90	4.04	1.78	2.52
5. (Complete fertilizer plat),	Grain,	18.9	14.08	6.68	.36	2.28	2.73	1.42	8.17	1.00	.09
	Straw and chaff,	7.8	14.96	21.62	.88	4.31	2.73	1.04	3.24	2.08	2.19
	Whole plant,	12.0	14.63	16.00	.68	3.54	2.73	1.18	5.10	1.67	1.40

*Roots not included.

Table VI.—Showing the Relative Amounts of Nitrogen and Protein in a Given Weight of the Crop from the Several Plats.

	Unfertilized plat.	Nitrogen plat.	Phosphoric acid plat.	Potash plat.	Complete fertilizer plat.
Grain,	100	108.6	83.2	96.8	77.4
Straw and husks,	100	100.9	82.2	98.1	88.7
Whole plant,	100	111.4	87.6	91.4	74.3

Table VII.—Showing the Relative Amounts of Phosphoric Acid in a Given Weight of the Crop from the Several Plats.

	Unfertilized plat.	Nitrogen plat.	Phosphoric acid plat.	Potash plat.	Complete fertilizer plat.
Grain,	100	110.7	125.1	109.2	141.1
Straw and husks,	100	105.4	170.3	95.2	160.4
Whole plant,	100	110.5	142.3	107.4	135.6

Table VIII.—Showing the Relative Amounts of Potash in a Given Weight of the Crop from the Several Plats.

	Unfertilized plat.	Nitrogen plat.	Phosphoric acid plat.	Potash plat.	Complete fertilizer plat.
Grain,	100	102.7	113.4	113.6	113.8
Straw and husks,	100	84.4	85.1	154.8	138.5
Whole plant,	100	85.2	93.1	142.0	144.3

The effects of the several systems of fertilizing upon the composition of the crop as respects nitrogenous in comparison with nitrogen-free matters, have been discussed in an earlier paragraph upon the basis of the figures in Table II. They are very clearly exhibited in Table VI.

From Table VII, it is clear that the proportion of phosphoric acid to total dry matter was slightly increased by the use of even non-phosphatic fertilizers (though dried blood, the source of nitrogen,

does contain a small proportion of phosphoric acid); that, however, where phosphates were used, the proportion of phosphoric acid in the dry matter of the total crop and in that of both the main parts, grain and straw, was greatly increased.

Table VIII shows that. on the soil upon which this series of experiments has been conducted, the use of potassic fertilizers does not so greatly affect the composition of the grain as does phosphatic fertilizers, but that its effects upon the composition of the straw is almost as marked as those of phosphates.

ACTUAL AMOUNTS OF FERTILIZER CONSTITUENTS REMOVED.

The absolute quantities, in pounds per acre, removed by the several crops above considered, are stated in Table IX.

*Table IX.—Showing the Amounts of Fertilizing Material Removed per Acre.**

	Nitrogen Removed Per Acre.			Phosphoric Acid Removed Per Acre.			Potash Removed Per Acre.		
	Grain.	Straw and chaff.	Total.	Grain.	Straw and chaff.	Total.	Grain.	Straw and chaff.	Total.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1. (Unfertilized plat), ...	17.51	14.40	31.91	4.77	2.76	7.53	4.84	21.33	26.17
2. (Nitrogen plat), ...	17.32	16.09	33.41	5.15	2.93	8.08	4.85	18.14	22.99
3. (Phosphoric acid plat), ...	18.83	15.76	34.59	8.31	5.89	14.20	7.16	23.37	30.53
4. (Potash plat), ...	17.78	13.18	30.96	5.39	2.65	8.04	5.68	33.18	38.86
10. (Complete fertilizer plat), .. .	22.43	17.40	39.83	9.72	7.24	16.96	7.95	48.38	56.33

*Calculated from the yield for the one-eighth acre plats and the composition of the samples, assuming that the field-cured crop and the laboratory air-dry samples contained the same amounts of hygroscopic moisture.

In this table are exhibited the combined results of the two factors, crop yield and crop composition, which have been separately considered in earlier paragraphs. These results show:

(a) That nitrogen applied alone caused a slightly increased nitrogen consumption, but depressed that of potash.

(b) That potash alone greatly increased potash consumption, chiefly through storage in the straw, and slightly depressed nitrogen consumption.

(c) That neither of these single additions affected, in considerable measure, the phosphoric acid consumption.

(d) That phosphoric acid applied alone led to the consumption not only of nearly double the quantity of this constituent consumed by the unfertilized crop, but also of distinctly greater quantities of nitrogen and potash.

(e) Finally, that the application of the complete fertilizer led to an increase in the consumption of each of the three constituents in amounts superior to the algebraic sum of the increases caused

by the application of nitrogen, phosphoric acid and potash singly. In this connection, it should be borne in mind, that the same one-sided fertilization has been continued for almost twenty-five years upon the plats whose crops are under study. These data do not warrant the conclusion that the complete fertilizer is the most productive and economical under all circumstances.

Note.—Other investigators have compared the relations of the several fertilizer constituents in the grain, and supposed that, from their ratios, valuable suggestions might be gained respecting the deficiencies of the soil in particular food constituents.

The ratios for the grain of our crop, computed from data of Table V, are:

Treatment.	Nitrogen.	Phosphoric acid.	Potash.
Unfertilized,	100	27.2	27.6
Dried blood,	100	29.8	28.0
Dissolved bone-black,	100	44.2	38.1
Muriate of potash,	100	30.2	31.9
Complete fertilizer,	100	43.2	35.3

Atterburg concluded that if the ratio of nitrogen to phosphoric acid were less than 100:50, the crop would not be maximum, if less than 100:20, the soil was actually deficient in phosphoric acid. Stahl-Shroder believes the ratio 100:30-40 to be the most favorable; while a ratio of 100:20-30 indicates a relative deficiency of phosphoric acid.

In our own samples, the maximum production, accompanied by a large increase in the richness of the grain in phosphoric acid, shows a nitrogen-phosphoric acid ratio of more than 100:40.

Likewise with respect to the nitrogen-potash ratio, the grain from the largest crops contained 100:35 or more. It is noteworthy, however, that the highest proportion of potash to nitrogen in the grain appeared where dissolved bone-black alone was applied. The deficiency was clearly not potash, but phosphoric acid, of which not enough was present to insure the maximum crop vigor. W. F.

Cf. J. König, Ldw. v. Stat., 61 (1905), 380 seq.

REPORT OF THE COMPOSITION OF MILK FROM HERDS COMPETING FOR ADVANCED REGISTRATION.

BY. M. H. PINGREE.

In co-operation with the Dairy Breeders' Association and in connection with the advanced registration of dairy cows, the Station has made the official examination of about 1,500 milk samples representing the product of 128 cows from 11 herds.

Some of the more extended series of observations are given on the following pages as a contribution to the knowledge concerning the milk variations in high-class animals of the several breeds represented.

The data gathered have been discussed in the following pages, those of the Guernsey breed with respect to the changes of composition during the lactation period, and with respect to the influence upon milk composition of the change from barn-feeding to pasturage; and those of both Guernsey and Ayrshire breeds with respect to the relative variability in composition of milks from a breed yielding very rich milk as compared with a breed yielding milk of moderate richness.

SUMMARY OF CONCLUSION.

Changes during Advance of Lactation Period: The percentages of butter-fat showed on the average a tendency to increase throughout the entire lactation period, but the increase was most marked during the first five months and last month.

Effect of changes from Barn to Pasture: The percentage of solids-not-fat decreased somewhat as the lactation period advanced. In the majority of cases studied, both the percentages of fat and the solids-not-fat, but particularly the latter, suffered a slight depression immediately following the change of the animals from barn to pasture, but tended to increase thereafter, under the influence of advancing lactation. The average fat results, however, were somewhat higher for the pasture months than for the barn period, due, propably, to a disproportionately large number of the cows being in an advanced stage of lactation during the summer months.

Relative variability of Guernsey and Ayrshire Milks: The range of variation in the percentages of fat for both the Guernsey and Ayrshire breeds was about 39 per cent. of the respective fat averages, which were 5.13 per cent. for the Guernseys, and 4.09 per cent. for the Ayrshires.

SAMPLING AND ANALYSIS OF MILKS.

All of the analytical work herein reported was performed by different members of the Station laboratory force. All of the Hol-

stein-Friesian stable tests were also conducted by assistant chemists of the Station. The Guernsey tests were in the immediate charge of Mr. S. I. Murphy, a graduate of The Pennsylvania State College Dairy School, who, by proper authorization, acted as special agent in the performance of this work. The weighings of the product, except those for the scattered milkings, included in the average daily yield, and the sampling for analysis were done by him.

By direction of the Ayrshire Breeders' Association, the milk samples from the Ayrshire herds were taken by the owners of the herds or persons in their employ. Their work, however, was liable to inspection, at all times and without notice, by Station officials.

The methods of analysis consisted of the usual Babcock test for butter-fat, and the lactometer method for the determination of density (specific gravity) expressed in terms of the lactometer reading. The percentages of solids and solids-not-fat were estimated from the data furnished by the fat test and the lactometer reading, according to the Babcock formula.

The milk from the Holstein-Friesian herds was tested while in a fresh condition, without the use of preservatives. The samples from the Guernsey herds were kept in a suitable condition for analysis by the use of solid preservatives. The milk from the Ayrshire cows was preserved by a water solution of formaldehyde. Since the milk is incapable of dissolving more than a small amount of the solid substance used as preservative, it is not probable that the lactometer reading was appreciably affected. When liquid preservatives were used, it is possible that large enough quantities were added to lessen the density and thus show a somewhat too low lactometer reading and correspondingly low percentages of solids and solids-not-fat.

Guernsey Breed.

The records of 18 individual cows are given in the following tables:

TABLE I.—Description: Breed, Guernsey. Owned by C. A. Griscom, Haverford, Pa. Name, Auto-Light. (Register No. 14849.) Born February 3, 1902. Commencement of Lactation Period, October 4, 1904.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
October 17, 1904, ...	35.38	4.80	14.61	9.81	24.0	1.152	3.506	(3) 22.0	10 lbs. mixed grains, pasture.
November 24, 1904, ...	35.40	5.22	15.11	9.89	26.0	1.357	3.928	(6) 23.7	10 lbs. gluten, 40 lbs. silage, 20 lbs. beets, fodder ad lib.
December 14, 1904, ...	36.50	5.41	15.62	10.21	25.0	1.353	2.553	(6) 23.5	6 lbs. gluten feed, 3 lbs. cotton-seed meal, 40 lbs. silage, 10 lbs. beets, corn stover ad lib.
January 30, 1905, ...	34.40	5.61	15.35	9.74	20.75	1.164	3.185	(7) 21.0	8 lbs. gluten meal, 4 lbs. cotton seed meal, 35 lbs silage, corn stover ad lib.
February 21, 1905, ...	35.40	5.52	15.47	9.95	18.75	1.035	2.901	(5) 20.2	8 lbs. gluten feed, 4 lbs. cotton-seed meal, 35 lbs. silage, corn stover ad lib.
March 21, 1905, ...	35.80	5.85	16.00	10.15	18.75	1.097	3.000	(6) 17.5	6 lbs. gluten feed, 2 lbs. cotton-seed meal, 4 lbs. bran, 20 lbs. silage, fodder and hay ad lib.
April 29, 1905, ...	34.00	6.51	16.31	9.80	13.50	.879	2.202	(6) 16.4	6 lbs. gluten feed, 3 lbs. cotton-seed meal, 5 lbs. bran, corn stover.
May 27, 1905, ...	*34.00	*5.20	*14.74	*9.54	.....	.....	.....	(5) 15.0	8 lbs. gluten feed, pasture.
June 14, 1905, ...	31.20	5.75	14.70	8.95	15.13	.870	2.224	(4) 14.6	4 lbs. gluten feed, pasture.
July 27, 1905, ...	32.78	5.48	14.87	9.39	14.25	.781	2.119	(5) 14.3	6 lbs. mixed grains, green corn, pasture.
August 24, 1905, ...	32.05	6.24	15.50	9.26	11.13	.695	1.725	(5) 12.8	8 lbs. gluten feed, green corn, pasture.
September 25, 1905, ...	33.5	6.26	15.89	9.63	9.75	.610	1.549	(5) 9.8	9 lbs. gluten feed, pasture.
October 26, 1905, ...	34.6	5.11	14.78	9.67	16.88	.863	2.495	(6) 13.9	10 lbs. crushed oats, 60 lbs. beets, 30 lbs. silage.

*Morning's milking only.
( )Number of days represented in the average milk yield.

TABLE II.—Description: Breed, Guernsey. Owned by C. A. Griscom, Haverford, Pa. Name, Sylphama. (Register No. 15044.) Born May 30, 1902. Commencement of Lactation Period, December 9, 1904.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield, Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
January 30, 1905, ...	33.3	4.32	13.68	9.37	30.63	1.320	4.190	(7) 38.3	4 lbs. cotton-seed meal, 8 lbs. gluten meal, 35 lbs. silage, corn stover ad lib.
February 21, 1905, ...	†35	4.47	†14.15	†9.75	27.25	1.218	3.855	(5) 25.6	4 lbs. cotton-seed meal, 8 lbs. gluten meal, 35 lbs. silage, corn stover ad lib.
March 21, 1905, ...	35.6	4.46	14.25	9.79	24.75	1.104	3.527	(6) 24.1	2 lbs. cotton-seed meal, 6 lbs. gluten meal, 4 lbs. wheat bran, 20 lbs. silage, hay ad lib.
April 29, 1905, ...	34.2	4.52	13.98	9.46	24.25	1.046	3.390	(6) 23.4	3 lbs. cotton-seed meal, 6 lbs. gluten feed, 5 lbs. wheat bran, corn stover, silage, until April 12.
May 29, 1905, ...	*34.0	*4.3	*13.66	*9.36	.....	.....	.....	(5) 23.8	8 lbs. gluten feed, pasture.
June 13, 1905, ...	33.0	4.25	13.35	9.10	20.38	.866	2.621	(4) 23	4 lbs. gluten feed, pasture.
July 27, 1905, ...	32.3	42.5	13.45	8.97	23.25	.988	3.127	(5) 19.94	6 lbs. mixed grains, green corn, pasture.
August 24, 1905, ...	33.0	4.47	13.60	9.14	18.50	.827	2.516	(6) 19.27	8 lbs. gluten feed, green corn, pasture.
September 25, 1905, ...	37.7	4.18	14.43	10.25	19.25	.805	2.778	(6) 18.0	9 lbs. gluten feed, pasture.
October 26, 1905, ...	34.3	4.41	13.86	9.45	16.50	.728	2.282	(6) 15.7	10 lbs. crushed oats, 60 lbs. beets, 30 lbs. silage.
November 29, 1905, ...	34.0	4.71	14.15	9.44	15.75	.704	2.229	(7) 17.0	8 lbs. crushed oats, 2 lbs. gluten, 50 lbs. beets, 30 lbs. silage.
December 21, 1905, ...	34.0	4.86	14.29	9.43	15.34	.746	2.192	(5) 16.7	10 lbs. crushed oats, 60 lbs. beets, 40 lbs. silage.

*Morning's milking only.
†Night's milking only.
( )Number of days represented in the average milk yield.

TABLE III.—Description: Breed, Guernsey. Owned by C. A. Griscom, Haverford, Pa. Name, Darthea. (Register No. 10073). Born January 10, 1894. Commencement of Lactation Period, September 12, 1904.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
September 27, 1904, ...	36.8	4.12	14.14	10.02	32.95	1.329	4.560	(5) 29.8	10 lbs. mixed grains, pasture and green sorghums.
October 17, 1904, ...	32.8	5.05	14.29	9.24	34.50	1.742	4.930	(5) 31.5	
November 24, 1904, ...	35.6	4.78	14.64	9.84	27.50	1.315	3.026	(7) 27.8	10 lbs. gluten feed, 20 lbs. beets, 40 lbs. silage, hay once a day, fodder ad lib.
December 14, 1904, ...	36.2	5.33	15.47	10.14	27.13	1.446	4.197	(6) 25.9	8 lbs. gluten feed, 15 lbs. beets, 40 lbs. silage, 40 lbs. cotton-seed meal, corn stover ad lib.
January 30, 1905, ...	34.4	5.38	15.04	9.66	25.50	1.372	3.253	(7) 24.5	8 lbs. gluten meal, 35 lbs. silage, 4 lbs. cotton-seed meal, corn stover ad lib.
February 21, 1905, ...	33.4	5.40	14.82	9.42	25.62	1.383	3.797	(5) 23.1	8 lbs. gluten feed, 35 lbs. silage, 4 lbs. cotton-seed meal, corn stover ad lib.
March 21, 1905, ...	36.7	5.46	15.68	9.22	22.50	1.229	3.528	(6) 20.3	6 lbs. gluten feed, 20 lbs. silage, 2 lbs. cotton-seed meal, 4 lbs. bran, hay and fodder ad lib.
April 29, 1905, ...	35.0	6.09	16.06	9.97	18.62	1.134	2.990	(6) 18.4	6 lbs. gluten feed, 3 lbs. cotton-seed meal, 5 lbs. bran, corn stover.
May 27, 1905, ...	*34.0	*4.70	*14.14	*9.44	.....	.....	.....	(5) 20.1	8 lbs. gluten feed, pasture.
June 14, 1905, ...	30.0	6.26	15.01	8.75	15.25	.954	2.293	(4) 15.9	4 lbs. gluten feed, pasture.
July 27, 1905, ...	34.2	3.83	13.16	9.33	6.87	.263	.904	(5) 17.6	6 lbs. mixed grains, green corn, pasture.
August 24, 1905, ...	32.8	5.30	14.55	9.25	13.00	.689	1.892	(6) 10.0	8 lbs. gluten feed, green corn, pasture.
September 25, 1905, ...	34.0	5.09	14.71	9.62	10.25	.522	1.568	(6) 10.6	9 lbs. gluten feed, pasture.

*Morning's milking only.
( )Number of days represented in the average milk yield.

TABLE IV.—Description: Breed, Guernsey. Owned by C. A. Griscom, Haverford, Pa. Name, Madras. (Register No. 12063.) Born April 2, 1897. Commencement of Lactation Period, November 17, 1903.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
December 20, 1903, ...	36.8	5.27	15.53	10.26	26.1	1.375	4.053	(6) 26.5	4 lbs. cotton-seed meal, 6 lbs. gluten feed, 16 lbs. beets, 36 lbs. silage, hay ad lib.
January 12, 1904, ...	38.05	5.62	16.27	10.65	25.75	1.447	4.190	(6) 26.3	
February 12, 1904, ...	.....	.....	.....	.....	23.37	.....	.....	.....	6 lbs. cotton-seed meal, 4 lbs. gluten meal, 40 lbs. silage, hay ad lib.
March 29, 1904, ...	†36.0	†5.95	†16.14	†10.19	18.25	1.086	2.946	(10) 18.4	6 lbs. cotton-seed meal, 6 lbs. gluten meal, 30 lbs. silage, hay ad lib.
April 27, 1904, ...	32.8	6.08	15.52	9.24	16.00	.973	2.483	(7) 18.3	6 lbs. cotton-seed meal, 4 lbs. gluten meal, silage until April 25.
May 20, 1904, ...	34.5	5.73	15.57	9.89	15.62	.895	2.432	(6) 17.2	2 lbs. cotton-seed meal, 2 lbs. gluten meal, pasture.
June 20, 1904, ...	32.3	5.56	14.76	9.08	16.74	.931	2.471	(6) 17.0	5 lbs. cotton-seed meal, 4 lbs. gluten meal, green oats and peas, pasture.
July, 1904, ...	*33.8	*5.5	*15.05	9.55	.....	.....	.....	.....	
August 25, 1905, ...	*34.0	5.61	15.15	9.59	12.25	.687	1.856	(7) 12.4	6 lbs. mixed grains, green corn, pasture.

*Morning's milking only.
†Night's milking only.
( )Number of days represented in the average milk yield.

TABLE V.—Description: Breed, Guernsey. Owner, C. A. Griscom, Haverford, Pa. Name, Lady Irwin of Highland. (Register No. 15418.) Born November 23, 1900. Commencement of Lactation Period, November 30, 1903.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
December 21, 1903, ...	34.5	4.93	14.54	9.61	27.63	1.362	4.017	(5) 31.1	6 lbs. gluten feed, 4 lbs. cotton-seed meal, 16 lbs. beets, 30 lbs. silage, hay ad lib.
January 12, 1904, ...	35.3	5.52	15.43	9.91	25.75	1.421	3.873	(5) 25.9	Not given.
February 12, 1904, ...	.....	.....	.....	.....	24.87	.....	.....	(7) 25.2	6 lbs. cotton-seed meal, 4 lbs. gluten meal, 40 lbs. silage, hay ad lib.
March 29, 1904, ...	*35.0	*5.3	*15.11	*9.81	21.75	1.153	3.286	(7) 22.2	6 lbs. cotton-seed meal, 4 lbs. gluten meal, 40 lbs. silage, hay ad lib.
April 27, 1904, ...	33.08	6.03	15.50	9.47	17.25	1.040	2.674	(6) 20.3	6 lbs. cotton-seed meal, 4 lbs. gluten meal, 40 lbs. silage, hay ad lib.
May 20, 1904, ...	33.0	5.38	14.71	9.33	18.00	.968	2.648	(6) 19.0	2 lbs. gluten meal, 2 lbs. cotton-seed meal, pasture.
June 20, 1904, ...	31.84	5.19	14.19	9.00	21.13	1.096	2.998	(5) 20.4	4 lbs. gluten meal, 5 lbs. cotton-seed meal, pasture, green oats and peas.
July, 1904, ...	34.2	†5.5	†15.03	†9.53	.....	.....	.....	.....	
August 25, 1904, ...	33.0	5.85	15.25	9.40	18.50	1.082	2.821	(7) 18.5	6 lbs. mixed grains, pasture, green corn.
September 27, 1904, ...	33.8	5.78	15.36	9.58	13.50	.780	2.074	(6) 16.4	10 lbs. mixed grains, pasture and green sorghum.
October 17, 1904, ...	33.4	5.40	15.11	9.71	10.80	.583	1.632	(5) 12.6	10-15 lbs. silage, pasture.
November 24, 1904, ...	32.0	6.54	15.86	9.32	5.25	.343	.832	(7) 8.9	40 lbs. silage, hay and corn stover ad lib.

*Morning's milking only.
†Night's milking only.
( )Number of days represented in the average milk yield.

TABLE VI.—Description: Breed, Guernsey. Owner, C. A. Griscom, Haverford, Pa. Name, Sweet Clover. (Register No. 6650.) Born January 4, 1893. Commencement of Lactation Period, March 10, 1904.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Rations.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
March 29, 1904,	*32.0	*4.65	*13.59	*8.84	40.25	1.872	5.469	(6) 40.9	2 lbs. cotton-seed meal, 3 lbs. gluten meal, 30 lbs. silage.
April 27, 1904,	33.5	4.68	13.99	9.31	38.75	1.814	5.421	(6) 41.6	6 lbs. cotton-seed meal, 4 lbs. gluten meal, hay and silage until April 25.
May 20, 1904,	34.0	4.56	13.95	9.39	34.0	1.550	4.743	(6) 35.6	2 lbs. cotton-seed meal, 2 lbs. gluten meal, pasture.
June 20, 1904,	32.9	4.04	13.05	9.01	36.12	1.592	4.713	(7) 33.4	5 lbs. cotton-seed meal, 4 lbs. gluten meal, green oats and peas, pasture.
July, 1904,	34.3	4.15	*13.62	*9.42	.....	.....	.....	.....	
August, 1904,	33.3	4.92	14.23	9.31	28.75	1.415	4.091	(7) 27.8	6 lbs. mixed grains, green corn, pasture.
September 27, 1904,	34.4	4.82	14.40	9.58	25.5	1.229	3.672	(5) 22.6	10 lbs. mixed grains, green sorghum, pasture.
October 17, 1904,	32.3	5.33	14.47	9.14	14.2	.757	2.055	(5) 17.5	10-15 lbs. silage, pasture.
November 24, 1904,	34.1	5.40	14.99	9.59	14.75	.797	2.211	(6) 16.7	10 lbs. gluten feed, 40 lbs. silage, hay and fodder ad lib.
December 12, 1904,	33.8	6.78	16.58	9.80	11.75	.797	1.948	(5) 16.6	8 lbs. gluten feed, 4 lbs. cotton-seed meal, 40 lbs. silage, 15 lbs. beets, corn stover ad lib.

*Morning's milking only.
( )Number of days represented in the average milk yield.

TABLE VII.—Description: Breed, Guernsey. Owned by C. A. Griscom, Haverford, Pa. Name, Moverina. (Register No. 9818.) Born June 14, 1897. Commencement of Lactation Period, November 30, 1903.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
December 20, 1903, ...	37.3	4.96	15.26	10.31	36.25	1.798	5.432	(6) 34.2	6 lbs. gluten feed, 4 lbs. cotton-seed meal, 16 lbs. beets, 36 lbs. silage, hay ad lib.
January 12, 1904, ...	36.04	5.20	15.24	10.04	33.5	1.742	5.095	(7) 34.5	Not given.
March 29, 1904, ...	*32.0	5.25	*14.24	*9.04	.....	.....	.....	(7) 30.5	6 lbs. cotton-seed meal, 6 lbs. gluten feed, 30 lbs. silage, hay ad lib.
April 27, 1904, ...	35.03	6.00	16.02	10.02	24.38	1.463	3.906	(7) 27.2	6 lbs. cotton-seed meal, 4 lbs. gluten feed, hay and silage.
May 19, 1904, ...	35.03	5.33	15.16	9.80	22.25	1.186	3.373	(6) 28.6	2 lbs. cotton-seed meal, 2 lbs. gluten meal, pasture.
June 20, 1904, ...	33.8	4.64	14.59	9.37	27.88	1.294	4.068	(6) 26.9	5 lbs. cotton-seed meal, 4 lbs. gluten meal, pasture, peas and oats.
July, 1904, ...	33.8	*4.7	13.86	9.36	.....	.....	.....	.....	
August 25, 1904, ...	33.3	5.03	14.36	9.33	13.38	.673	1.921	(7) 20.6	6 lbs. mixed grains, pasture and green corn.
September 27, 1904, ...	34.5	5.20	14.62	9.42	15.00	.780	2.193	(6) 15.4	10 lbs. mixed grains, pasture and green sorghums.
October 17, 1904.	34.0	4.77	14.38	9.56	7.70	.367	1.107	(6) 12.5	No grain after Oct. 11, pasture, 10-15 lbs. silage.
November 24, 1904, ...	37.4	5.96	16.50	10.54	4.75	.283	.784	(6) 5.2	40 lbs. silage, hay and corn stover ad lib.

*Morning's milking only.
( )Number of days represented in the average milk yield.

TABLE VIII.—Description: Breed, Guernsey. Owner, Hollingsworth Bros., Landenberg. Name, Alta s Jewel. (Register No. 15924.) Born March 30, 1902. Commencement of Lactation Period, July 30, 1904.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
Sept. [illegible]	*[illegible]	*3.8	*13.56	*9.76	.....	.....	.....	.....	
October 29, 1904, ...	33.0	4.74	13.93	9.19	16.87	.799	2.350	(6) 16.9	8 lbs. bran, hay, silage, pasture.
November 22, 1904, ...	35.4	5.00	14.85	9.85	13.50	.675	2.005	(6) 13.8	7 lbs. bran, 5 lbs. gluten feed, 1 bu. silage, hay and stover, pasture.
December 15, 1904, ...	.....	5.03	.....	.....	9.50	.478	.....	(5) 10.5	5 lbs. bran, 4 lbs. gluten feed, 30 lbs. silage, hay and fodder.
January 28, 1905, ...	37.5	4.75	15.08	10.33	12.50	.594	1.885	(6) 11.9	1 lb. bran, 2 lbs. gluten feed, 1 lb. cotton-seed meal, 2 lbs. distillers' grains, hay, fodder, silage.
February, 1905, ...	†35.0	†5.4	.....	.....	.....	.....	.....	.....	
March 18, 1905, ...	36.0	4.95	14.94	9.99	11.87	.587	1.773	(6) 11.9	2 lbs. bran, 2½ lbs. brewers' grains, 3 lbs. gluten feed, hay, fodder.
April 19, 1905, ...	34.3	4.87	14.12	9.55	10.00	.487	1.412	(5) 10.1	2 lbs. bran, 2 lbs. brewers' grains, 4 lbs. gluten feed, 25 lbs. silage, hay and fodder ad lib.
May 27, 1905, ...	33.8	5.12	14.59	9.47	12.88	.669	1.879	(7) 12.4	8 lbs. mixed grains, pasture.
June 23, 1905, ...	34.0	5.07	14.58	9.51	12.25	.621	1.786	(5) 13.4	4 lbs. bran and corn meal, silage and pasture.
July 13, 1905, ...	33.5	5.79	15.34	9.55	11.50	.666	1.764	.....	3½ lbs. bran, 3½ lbs. corn meal, silage and pasture.

*Morning's milking only.
†Night's milking only.
( )Number of days represented in the average

TABLE IX.—Description: Breed, Guernsey. Owner, Hollingsworth Bros., Landenberg. Name, Vega 2d. (Register No. 15926.) Born September 14, 1902. Commencement of Lactation Period, September 19, 1904.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
October 29, 1904.	33.7	3.73	12.87	9.14	21.5	.802	2.767	(6) 20.2	8 lbs. wheat bran, hay, silage and pasture.
November 22, 1904.	35.4	4.01	13.66	9.65	17.12	.686	2.338	(6) 17.9	7 lbs. bran, 5 lbs. gluten feed, 1 bu. silage, hay and stover ad lib., pasture.
December 16, 1904, ...	.....	3.93	.....	.....	11.88	.467	.....	(4) 15.5	7 lbs. bran, 5 lbs. gluten feed, 36 lbs. silage, hay and fodder.
January 28, 1905, ...	36.0	4.05	13.86	9.81	17.5	.709	2.425	(6) 18.2	2 lbs. gluten feed, 2 lbs. distillers' grains, 1 lb. bran, 1 lb. cotton-seed meal, 5 lbs. hay, 10 lbs. fodder, 30 lbs. silage.
February 22, 1905, ...	34.6	4.15	13.61	9.46	16.75	.695	2.279	(6) 17.7	8 lbs. mixed grains, 30 lbs. silage, hay and stover ad lib.
March 18, 1905, ...	35.9	4.11	13.90	9.79	18.88	.754	2.604	(2) 17.9	2½ lbs. bran, 2½ lbs. brewers' grains, 3 lbs. gluten feed, 30 lbs. silage, hay and fodder ad lib.
April 19, 1905, ...	34.7	3.75	13.31	9.56	17.0	.638	2.262	(5) 16.7	2 lbs. bran, 2 lbs. brewers' grains, 4 lbs. gluten feed, 25 lbs. silage, hay and fodder ad lib.
May 27, 1905.	33.0	5.31	14.59	9.28	14.25	.756	2.079	(6) 17.3	8 lbs. mixed grains, pasture.
June 23, 1905, ...	33.2	5.04	14.35	9.31	16.25	.819	2.322	.....	2 qts. bran, 2 qts. corn meal, pasture.
July 13, 1905, ...	32.2	4.94	14.98	10.04	15.75	.778	2.359	(4) 17.3	3½ lbs. corn meal, 3½ lbs. bran, silage and pasture.
August 24, 1905, ...	32.6	5.37	14.61	9.24	15.0	.806	2.191	(6) 17.2	4 lbs. bran, 15 lbs. silage, pasture.
September 26, 1905.	34.0	5.60	15.22	9.62	13.0	.728	1.978	(6) 13.3	6 qts. bran, pasture.

( )Number of days represented in the average milk yield.

TABLE X.—Description: Breed, Guernsey. Owner, Prof. J. P. Wesh, Bloomsburg. Name, Dorothy Thorne. (Register No. 15333.) Born August 20, 1902. Commencement of Lactation Period, November 2, 1904.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
November 29, 1904,	35.8	4.64	14.52	9.88	15.00	.696	2.178	(6) 16.9	3 lbs. mids., 3 lbs. gluten, 40 lbs. silage, shredded fodder.
December 27, 1904,	.....	4.55	.....	.....	13.75	.625	.....	(6) 16.3	3 lbs. gluten feed, 3 lbs. buckwheat mids., 40 lbs. silage, shredded fodder.
January 25, 1905,	.....	4.22	.....	.....	15.75	.664	.....	(5) 16.9	8 lbs. mixed grains, 35 lbs. silage, hay and corn stover ad lib.
February 24, 1905,	35.0	4.58	14.22	9.63	13.50	.618	1.919	(6) 16.3	4 lbs. bran, 4 lbs. gluten feed, 1 lb. linseed meal, 30 lbs. silage.
March 22, 1905,	34.5	4.37	13.87	9.40	15.75	.688	2.184	(5) 15.6	1¾ lbs. bran, 4½ lbs. gluten feed, 1¾ lbs. linseed meal, 1 bu. silage, hay and fodder ad lib.
April 28, 1905,	35.8	4.73	14.89	9.48	12.00	.567	1.786	(7) 13.5	1½ lbs. bran, 6 lbs. gluten feed, 1½ lbs. linseed meal, 40 lbs. silage, hay and sheaf oats ad lib.
May 22, 1905,	35.3	4.73	14.50	9.79	13.50	.638	1.957	(6) 13.5	1½ lbs. bran, 6 lbs. gluten feed, 1½ lbs. linseed meal, 40 lbs. silage, sheaf oats ad lib.
June 27, 1905,	35.7	4.68	14.55	9.96	13.75	.633	2.000	(5) 14.5	4 lbs. mixed grains, 25 lbs. silage, alfalfa.
July 30, 1905,	36.6	4.42	14.45	9.99	11.50	.508	1.661	(5) 14.2	
August 28, 1905,	†33.5	5.30	.....	.....	11.00	.583	.....	(6) 12.1	5 lbs. bran, 5 lbs. gluten feed, 40 lbs. silage.

†Night's milking only.
( )Number of days represented in the average milk yield.

TABLE XI.—Description: Breed, Guernsey. Owner, Hollingsworth Bros., Landenberg, Pa. Name, Alta's Pearl. (Register No. 14278.) Born March 19, 1901. Commencement of Lactation Period, November 28, 1903.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
December 22, 1903, ...	35.4	4.32	14.03	9.71	23.5	1.015	3.297	(5) 22.9	3.4 lbs. gluten, 4.6 lbs. bran, 30 lbs. silage, 11 lbs. hay.
January 16, 1904, ...	35.3	4.52	14.30	9.88	21.0	.949	3.003	(7) 21.7	4½ lbs. bran, 3½ lbs. gluten feed, 30 lbs. silage, hay ad lib.
February 18, 1904, ...	33.2	4.59	13.81	9.22	18.00	.826	2.486	(8) 19.2	5 lbs. bran, 3 lbs. gluten feed, 30 lbs. silage, hay ad lib.
March 15, 1904, ...	34.4	4.43	13.90	9.47	21.26	.942	2.955	(7) 21.0	4½ lbs. bran, 3½ lbs. gluten meal, 30 lbs. silage, hay ad lib.
April 26, 1904, ...	34.7	4.05	13.56	9.51	18.25	.821	2.475	(8) 17.8	5 lbs. bran, 3 lbs. gluten meal, 30 lbs. silage, hay ad lib.
May 18, 1904, ...	33.0	4.36	14.08	9.72	16.25	.709	2.288	(6) 17.8	4½ lbs. bran, 3½ lbs. gluten meal, 30 lbs. silage, hay ad lib.
June 23, 1904, ...	33.9	4.23	13.59	9.36	23.12	.978	3.142	(7) 22.2	5 lbs. bran, 15 lbs. silage, pasture.
July 26, 1904, ...	33.8	4.50	13.83	9.33	18.76	.844	2.594	(6) 20.5	
August 11, 1904, ...	33.5	5.11	14.34	9.23	22.00	1,124	3.155	(5) 22.0	6 lbs. bran, 1½ lbs. cotton-seed meal, green corn, pasture.
September 8, 1904, ...	35.0	4.91	14.69	9.78	20.63	1.013	3.009	(5) 19.8	2 lbs. cotton-seed meal, 5 lbs. bran, pasture.
October 29, 1904, ...	36.5	5.00	14.91	9.91	10.75	.538	1.603	(6) 13.0	8 lbs. bran, pasture, silage, hay.
November 22, 1905, ...	36.0	6.10	16.30	10.20	6.37	.389	1.038	(6) 7.7	7 lbs. bran, 5 lbs. gluten feed, 1 bu. silage, hay, stover, pasture.

( )Number of days represented in the average milk yield.

TABLE XII.—Description: Breed, Guernsey. Owner, Prof. J. P. Welsh, Bloomsburg, Pa. Name, Juliet of Orange. (Register No. 14835.) Born March 28, 1902. Commencement of Lactation Period, July 31, 1904.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
August 27, 1904, ...	38.2	4.04	14.41	10.37	20.75	.838	2.990	(5) 20.25	7 lbs. mixed grains, 1 bu, silage, clover hay ad lib.
September 27, 1904, ...	†33.5	†4.50	†13.78	†8.28	.....	.....	.....	.....	
October, 1904, ...	34.3	4.65	14.20	9.26	13.25	.615	1.881	(7) 15.0	4 lbs. buckwheat mids., 4 lbs. gluten feed, 1 bu. silage, hay ad lib.
November 29, 1904, ...	35.0	5.09	14.87	9.78	12.50	.636	1.858	(7) 15.3	4 lbs. mids., 4 lbs. gluten, 40 lbs. silage, shredded fodder.
December 27, 1904, ...	.....	5.08	.....	.....	12.50	.635	.....	(6) 14.8	4 lbs. buckwheat mids., 4 lbs. gluten feed, shredded fodder.
January 25, 1905, ...	.....	4.72	.....	.....	13.25	.625	.....	(5) 13.2	8 lbs. mixed grains, 35 lbs. silage, hay and stover ad lib.
February 24, 1905, ...	34.0	4.45	13.84	9.33	11.25	.501	1.552	(5) 14.0	3 lbs. wheat, 4 lbs. gluten feed, 1 lb. linseed meal, 30 lbs. silage, hay ad lib.
March 22, 1905, ...	34.5	4.69	15.26	9.70	12.75	.598	1.945	(5) 11.8	1¾ lbs. bran, 4½ lbs. gluten, 1¾ lbs. linseed meal, 1 bu. silage, hay and fodder ad lib.
April 28, 1905, ...	34.9	5.03	14.76	9.95	4.50	.226	.664	(7) 7.1	1½ lbs. bran 6 lbs. gluten, 1½ lbs. linseed meal, hay and sheaf oats ad lib.
May 22, 1905, ...	*32.5	4.19	*12.81	*8.91	2.25	.094	.288	(6) 3.6	1½ lbs. bran, 6 lbs. gluten feed, 1½ lbs. linseed meal, 40 lbs. silage, sheaf oats ad lib.

*Morning's milking only.
†Night's milking only.
( )Number of days represented in the average milk yield.

TABLE XIII.—Description: Breed, Guernsey. Owner, E. W. Twaddell, Westtown. Name, Young Polly Vrangve. (Register No. 15116.) Born May 29, 1902. Commencement of Lactation Period, April 29, 1904.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
May 29, 1904, ...	34.7	5.24	14.97	9.73	24.5	1.283	3.668	(9) 25.8	6 qts. corn, bran, pasture.
June 24, 1904.	36.5	5.65	15.91	10.26	26.8	1.514	4.264	(5) 26.1	5 qts. maize feed, 1 qt. linseed meal, pasture.
July 14, 1904.	35.1	5.09	14.89	9.80	27.5	1.399	3.095	(6) 26.1	8 qts. mixed grains "feed," pasture.
August. 1904.	†33.5	†6.00	†15.58	†9.58	.....	.....	.....	.....	
September 27, 1904, ...	35.7	6.09	16.20	10.17	20.3	1.236	3.287	(8) 21.2	4 qts. dried brewers' grains, 10 qts. maizalene, 1 qt. linseed meal, pasture.
October 12, 1904, ...	35.0	6.30	16.31	10.01	17.9	1.128	2.919	(6) 19.3	10 qts. maizalene, 1½ qts. linseed meal, pasture.
November 23, 1904, ...	32.73	7.95	17.73	9.78	11.5	.914	2.039	(6) 14.3	10 qts. maizalene, 1 lb. linseed meal, pasture and corn stover.
December 12, 1904, ...	33.5	6.80	16.54	9.74	10.8	.734	1.786	(4) 11.4	10 qts. maizalene, 1 pt. linseed meal, corn stover.
January 27, 1905, ...	35.6	7.46	17.70	10.24	8.5	.634	1.505	(6) 9.0	8 lbs. maizalene, hay and corn stover ad lib.
February 20, 1905, ...	30.1	5.74	14.42	8.68	21.25	1.220	3.064	(4) 19.5	10 lb. mixture of bran and corn by-products, hay ad lib.
March 20, 1905, ...	34.8	6.30	16.26	9.96	17.10	1.077	2.780	(6) 18.2	12 qts. maizalene, 1 qt. linseed meal, mixed hay and fodder ad lib.

†Night's milking only.
( )Number of days represented in the average milk yield.

TABLE XIV.—Description: Breed, Guernsey. Owner, Prof. J. P. Welsh, Bloomsburg, Pa. Name, Estella Trink. (Register No. 14787.) Born March 17, 1902. Commencement of Lactation Period, February 7, 1904.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
February 24, 1904, ...	33.0	4.28	13.43	9.15	18.50	.792	2.484	(8) 18.0	
March 23, 1904, ...	34.5	5.12	14.79	9.67	16.75	.858	2.998	.....	8½ lbs. bran, 1½ lbs. linseed meal, 40 lbs. silage, hay ad lib.
April 24, 1904, ...	33.6	6.11	15.24	9.13	17.00	1.039	2.591	(6) 16.2	3½ lbs. bran, 5 lbs. gluten meal, 1½ lbs. linseed meal, 1 bu. silage, hay ad lib.
May 26, 1904, ...	35.1	5.13	14.92	9.79	19.75	10.13	2.946	(6) 18.7	3 lbs. bran, 1 lb. linseed meal, 3 lbs. gluten meal, 1½ lbs. corn, 1 bu. silage, hay ad lib.
June 25, 1904, ...	35.8	5.58	15.64	10.06	17.75	.990	2.776	(8) 20.0	10 lbs. mixed grains, 30 lbs. silage, hay ad lib.
July 22, 1904, ...	34.6	5.97	15.80	9.83	16.75	1.000	2.646	(6) 19.1	9 lbs. mixed grains, 1 bu. silage, clover hay ad lib.
August 29, 1904, ...	36.9	5.29	15.60	10.31	16.75	.886	2.613	(6) 17.7	10 lbs. mixed grains, 1 bu. silage, clover hay ad lib.
September 15, 1904, ...	31.7	5.48	14.48	9.00	16.50	.904	2.389	(5) 16.3	6 lbs. gluten, 1 bu. silage, clover hay ad lib.
October 25, 1904, ...	34.0	6.01	15.72	9.73	14.50	.871	2.279	(7) 16.0	4 lbs. gluten feed, 1 bu. silage, 4 lbs. buckwheat mids., hay ad lib.
November 29, 1904, ...	34.5	6.57	16.51	9.94	12.25	.805	2.022	(8) 14.4	4 lbs. gluten, 4 lbs. mids., 40 lbs. silage, fodder.
December 27, 1904, ...	.....	6.76	.....	.....	11.75	.794	.....	(6) 13.9	4 lbs. gluten, 4 lbs. buckwheat mids., 40 lbs. silage, shredded fodder.
January 25, 1905, ...	.....	6.35	.....	.....	10.50	.667	.....	(6) 10.8	8 lbs. mixed grains, 35 lbs. silage, hay and stover ad lib.
February 24, 1905, ...	*33.5	7.00	*16.42	*9.72	5.75	.403	9.44	(6) 9.8	3 lbs. bran, 4 lbs. gluten, 1 lb. linseed meal, 30 lbs. silage, hay ad lib.

*Morning's milking only.
( )Number of days represented in the average milk yield.

TABLE XV.—Description: Breed, Guernsey. Owner, Hollingsworth Bros., Landenberg. Name, Alta's Gem. (Register No. 8597.) Born August 18, 1895. Commencement of Lactation Period, December 20, 1904.

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
January 28, 1905, ...	35.7	34.5	13.07	9.62	33.25	1.147	4.446	(5) 34.5	2 lbs. gluten, 2 lbs. distillers' grains, 1 lb. bran, 1 lb. cotton-seed meal, 10 lbs. fodder, 30 lbs. silage.
February 22, 1905, ...	*33.5	3.60	*12.70	*9.10	30.00	1.080	3.810	(5) 33.0	8 lbs. mixed grains, 30 lbs. silage, hay and stover ad lib.
March 18, 1905, ...	33.7	3.74	12.88	9.30	30.00	1.122	3.864	(5) 30.2	2½ lbs. bran, 2½ lbs. brewers' grains, 3 lbs. gluten feed, 30 lbs. silage, hay and stover ad lib.
April 19, 1905, ...	33.6	3.80	12.95	9.01	28.75	1.093	3.723	(5) 29.4	2 lbs. bran, 2 lbs. brewers' grains, 4 lbs. gluten feed, 25 lbs. silage, hay and fodder ad lib.
May 27, 1905, ...	32.6	4.65	13.75	8.92	30.00	1.395	4.125	(7) 30.5	8 lbs. mixed grains, pasture.
June 23, 1905, ...	32.4	4.82	13.90	9.08	25.50	1.229	3.545	(5) 29.4	2 qts. bran, 2 qts. corn meal, pasture.
July 13, 1905, ...	29.5	6.05	14.77	8.40	24.75	1.497	3.656	(4) 26.8	3 lbs. corn meal, 3½ lbs. bran, silage and pasture.
August 22, 1905, ...	32.4	4.29	13.24	8.81	20.13	.864	2.665	(6) 21.9	4 lbs. bran, 15 lbs. silage, pasture.
September 26, 1905, ...	30.0	7.33	16.51	9.49	9.75	.715	1.609	(6) 14.9	6 qts. wheat bran, pasture.
October 25, 1905, ...	34.0	5.21	14.80	9.37	19.00	.990	2.812	(6) 12.6	4 qts. short corn, 6 qts. bran, 2 qts. gluten feed.
November 28, 1905, ...	35.1	4.54	14.23	9.43	16.12	.732	2.293	(7) 17.9	8 qts. bran and gluten, 1 bu. silage, hay and pasture.
December 18, 1905, ...	36.0	4.17	14.00	9.84	16.50	.688	2.310	(5) 15.7	2 lbs. bran, 2 lbs. gluten feed, 2 lbs. brewers' grains.

*Morning's milking only.
( )Number of days represented in the average milk yield.

TABLE XVI.—Description: Breed, Guernsey. Owner, Hollingsworth Bros., Landenberg. Name, Lady Trowbridge. (Register No. 14085.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
June 23, 1904, ...	33.5	4.25	13.45	9.20	26.38	1.121	3.547	(4) 26.5	5 lbs. bran, 15 lbs. silage, pasture.
July 26, 1904, ...	34.0	4.19	13.53	9.34	21.00	.880	2.841	(7) 23.6	6 lbs. bran, 1½ lbs. cotton-seed meal, silage, pasture.
August 11, 1904, ...	33.8	4.26	13.60	9.34	20.12	.857	2.736	(5) 23.2	6 lbs. bran, 1½ lbs. cotton-seed meal, green corn, pasture.
September 8, 1904, ...	34.2	4.25	13.66	9.78	24.00	1.020	3.278	(5) 23.7	5 lbs. bran, 2 lbs. cotton-seed meal, pasture.
October 29, 1904, ...	35.2	4.46	14.16	9.70	19.75	.871	2.796	(5) 20.7	8 lbs. bran, pasture, hay, silage.
November 22, 1904, ...	35.8	4.60	14.46	9.86	16.15	.743	2.335	.....	7 lbs. bran, 5 lbs. gluten feed, 1 bu. silage, hay and stover ad lib., pasture.
December 15, 1904, ...	.....	5.07	.....	.....	11.13	.558	.....	(6) 14.3	5 lbs. bran, 4 lbs. gluten feed, 30 lbs. silage, hay and fodder.
January 28, 1905, ...	35.8	4.75	14.65	9.90	8.37	.397	1.226	(6) 10.8	2 lbs. gluten feed, 2 lbs. distillers' grains, 1 lb. bran, 1 lb. cotton-seed meal, hay, fodder, silage.
February 22, 1905, ...	35.5	5.27	15.22	9.95	3.00	.158	.456	(5) 5.8	8 lbs. mixed grains, 30 lbs. silage, hay and stover.

( )Number of days represented in the average milk yield.

TABLE XVII.—Description: Breed, Guernsey. Owner, Pr of. J. P. Welsh, Bloomsburg, Pa. Name, Beauty of Orange. (Register No. 12891.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
April 16, 1904, ...	36.03	4.57	14.49	9.88	35.25	1.611	5.107	(7) 34.1	4 lbs. middlings, 4 lbs. corn and oats, 3 lbs. gluten, 3 lbs. bran, 20 lbs. silage, hay ad lib.
May 25, 1904, ...	34.50	4.65	14.21	9.56	35.87	1.668	5.097	35.2	4 lbs. mids., 4 lbs. corn and oats, 3 lbs. gluten meal, 3 lbs. bran, 20 lbs. silage, hay ad lib.
June 26, 1904, ...	35.50	4.25	13.98	9.73	36.50	1.551	5.101	(8) 35.3	10 lbs. of bran and mids., green clover.
July 22, 1904, ...	33.00	4.43	13.58	9.15	26.75	1.185	3.633	(7) 31.3	12 lbs. mixed grains, green corn ad lib.
August 18, 1904, ...	32.50	4.36	13.36	9.00	27.75	1.210	3.774	(5) 29.4	9 lbs. bran and mids., green corn ad lib.
September 17, 1904, ...	†32.00	†5.10	†14.12	†9.02	25.00	1.275	3.530	(6) 27.3	10 lbs. mixed grains, green corn.
October 26, 1904, ...	34.50	5.32	15.00	9.68	21.50	1.144	3.225	(6) 23.8	16 qts. of mixture of bran mids. and gluten, 1 bu. silage, hay ad lib.
November 24, 1904, ...	†34.50	†6.3	†16.19	9.89	.....	.....	.....	.....	
December 27, 1904, ...	.....	5.59	.....	.....	15.75	.880	.....	(6) 18.2	5 lbs. bran, 5 lbs. mids., 1 bu. silage, hay and stover ad lib.
January 25, 1905, ...	35.00	7.48	17.72	10.24	6.00	.448	1.063	(6) 8.7	4 lbs. bran, 4 lbs. mids., 30 lbs. silage, hay and stover ad lib.

†Night's milking only.
( )Number of days represented in the average milk yield.

TABLE XVIII.—Description: Breed: Guernsey. Owner, Prof. J. P. Welsh, Bloomsburg, Pa. Name, Ecstasy of Paxtang. (Register No. 12294.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.			Yield (Pounds).			Average daily milk yield. Lbs.	Ration.
		Fat.	Total solids.	Solids not fat.	Milk.	Fat.	Total solids.		
April 17, 1904,	*37.5	*2.9	*12.86	*9.96	.....	.....	.....	.....	Silage.
May 25, 1904,	34.5	5.25	14.93	9.73	28.0	1.470	4.180	(6) 28.8	4 lbs. mids., 3 lbs. bran, 3 lbs. gluten meal, 4 lbs. corn and oats, 20 lbs. silage, hay ad lib.
June 26, 1904,	34.8	4.76	*14.40	9.72	25.0	1.190	3.600	(8) 25.8	10 lbs. bran and mids., green clover.
July, 1904,	33.5	*4.50	13.78	9.24	.....	.....	.....	.....	
August 18, 1904,	34.5	4.41	13.54	9.47	18.5	.816	2.504	(5) 23.6	9 qts. bran and mids., green corn ad lib.
September 16, 1904,	33.5	5.33	14.77	9.46	20.0	1.066	2.954	(6) 22.6	10 lbs. mixed grains, green corn.
October 26, 1904,	33.5	5.84	15.39	9.35	14.25	.832	2.193	(6) 15.5	16 qts. of bran mids. and gluten feed, 1 bu. silage, hay ad lib.
November 28, 1904,	36.6	6.59	17.04	10.25	13.75	.906	2.343	(6) 15.3	10 lbs. mixed grains, 1 bu. silage, hay ad lib.
December 26, 1904,	.....	5.95	.....	.....	11.25	.669	.....	(6) 12.1	5 lbs. bran, 5 lbs. mids., 1 bu. silage, hay and stover ad lib.
January 25, 1905,	36.0	7.17	17.60	10.40	8.5	.609	1.496	(5) 8.9	4 lbs. bran, 4 lbs. mids., 30 lbs. silage, hay and stover ad lib.
February 23, 1905,	37.5	7.70	18.62	10.77	2.0	.154	.372	(6) 5.8	5 lbs. bran, 8 lbs. mids., 16 lbs. silage, hay ad lib.

*Morning's milking only.
( )Number of days represented in the average milk yield.

For convenience of comparison, with respect to variation in composition during lactation and with changes from barn to pasture, the data for the richness with respect to fat and solids-not-fat of the milks at various times during the lactation periods represented, have been chartered for fifteen Guernsey cows:

Changes During Lactation: In comparing the percentages in the foregoing tables and plates the first question considered is this: Do the percentages of butter-fat and solids-not-fat increase or decrease as the lactation period advances?

By dividing the lactation period of each of the 15 cows represented into sections of ten weeks each, not including a few single tests made after the fiftieth week, and averaging the results contained in each sub-period, the following period-averages are obtained:

	1st 10 weeks. Per cent.	2d 10 weeks. Per cent.	3d 10 weeks. Per cent.	4th 10 weeks. Per cent.	5th 10 weeks. Per cent.	Average. Per cent.
Fat,	4.67	4.76	5.17	5.33	5.51	5.09
Solids-not-fat,	9.79	9.61	9.59	9.44	9.59	9.60

The increase in fat and decrease in solids-not-fat, those of the first 10 weeks being taken as 100, may be expressed as follows:

	1st 10 weeks.	2d 10 weeks.	3d 10 weeks.	4th 10 weeks.	5th 10 weeks.
Fat,	100	102	111	114	118
Solids-not-fat,	100	98.2	98.0	96.4	98.0

By a comparison of the percentages from each of the several periods with those representing the average for all periods, the following data is obtained:

	Average of all periods.	1st 10 weeks.	2d 10 weeks.	3d 10 weeks.	4th 10 weeks.	5th 10 weeks.
Fat,	100	91.8	93.5	101.6	104.7	108.2
Solids-not-fat,	100	102	100.1	99.9	98.3	99.9

The diagrams for individual cows exhibit, however, very marked individuality in their variations. While it is true that each of the cows represented showed at some time after the first ten weeks milk richer than that given during the first period, three exhibited at

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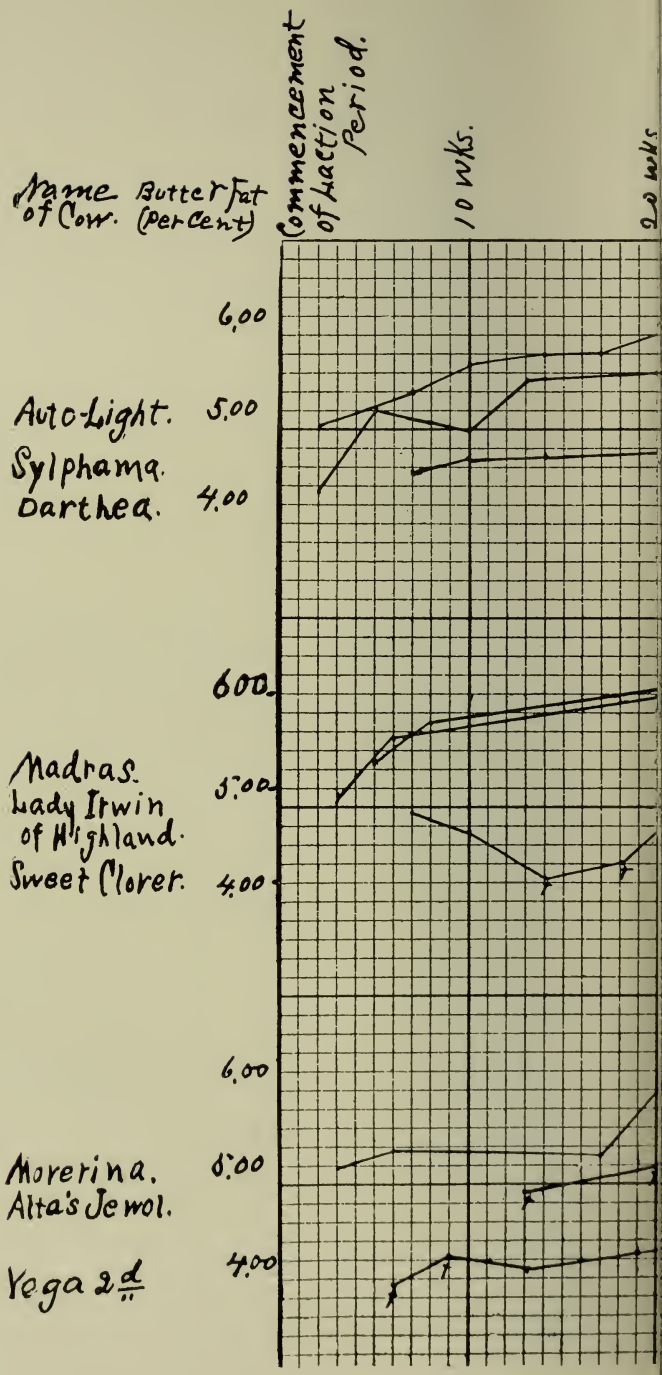

Plate 1.—Showing

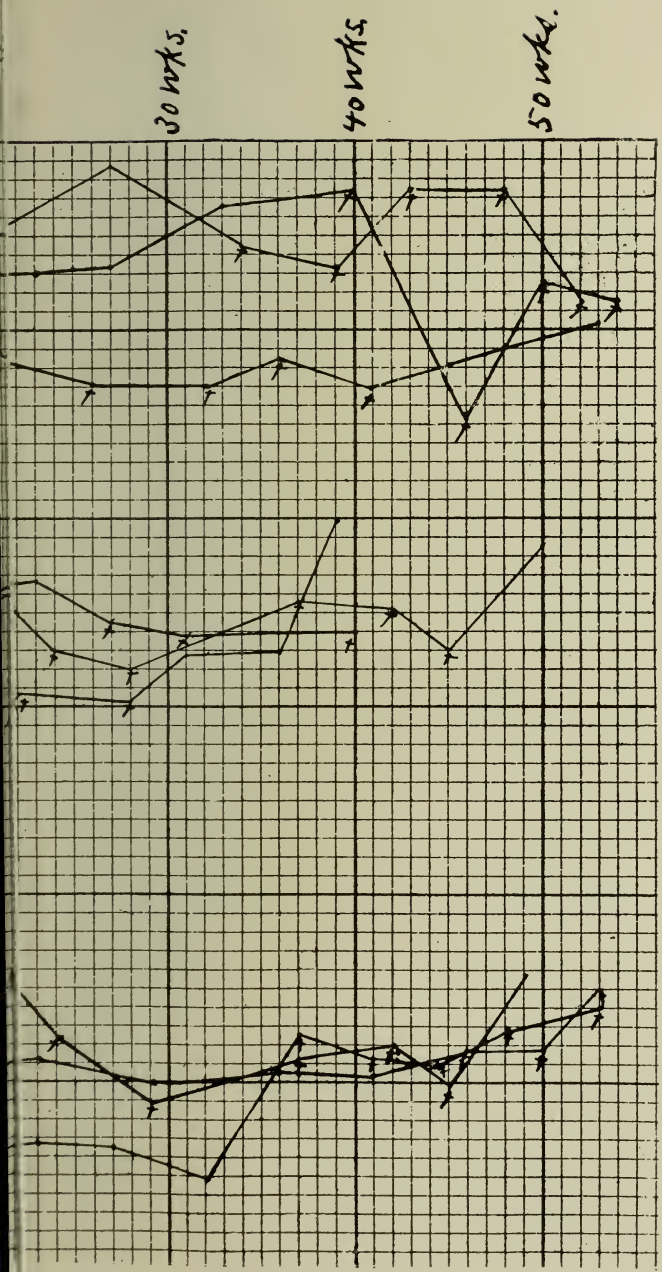

CHART I.

riation in the Percentage of Butter Fat.

†Cow at pasture.

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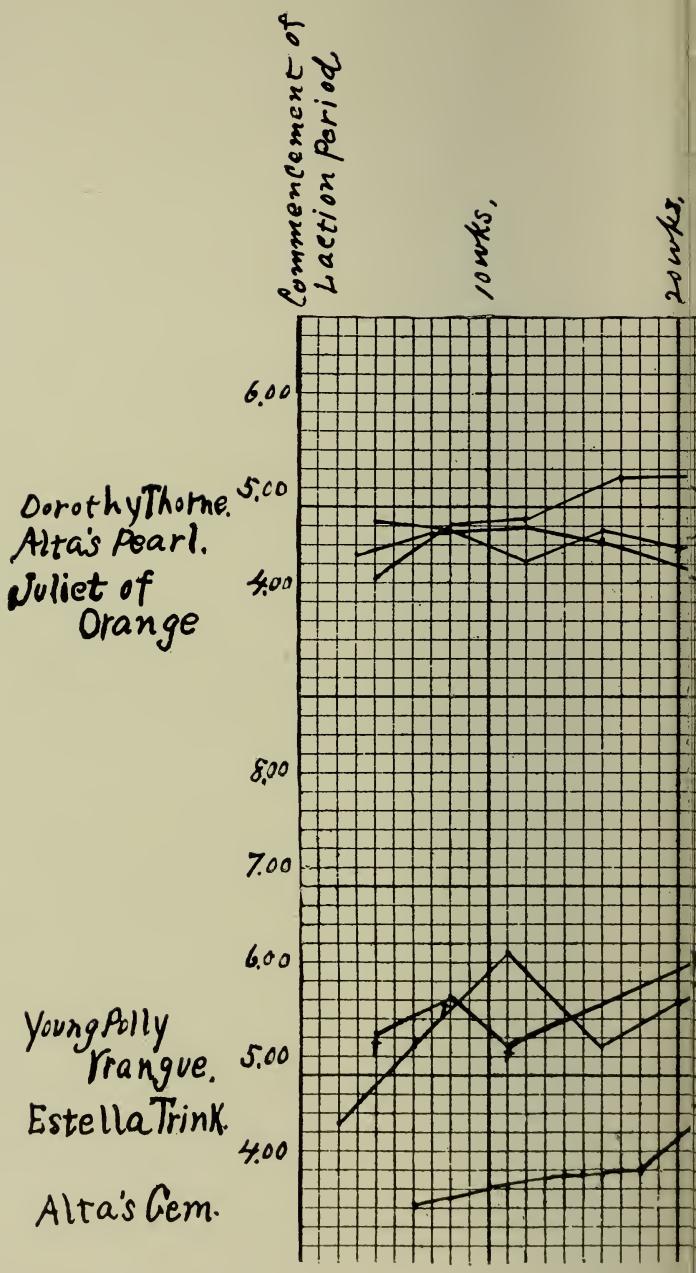

Plate 1.—Continued.—Show

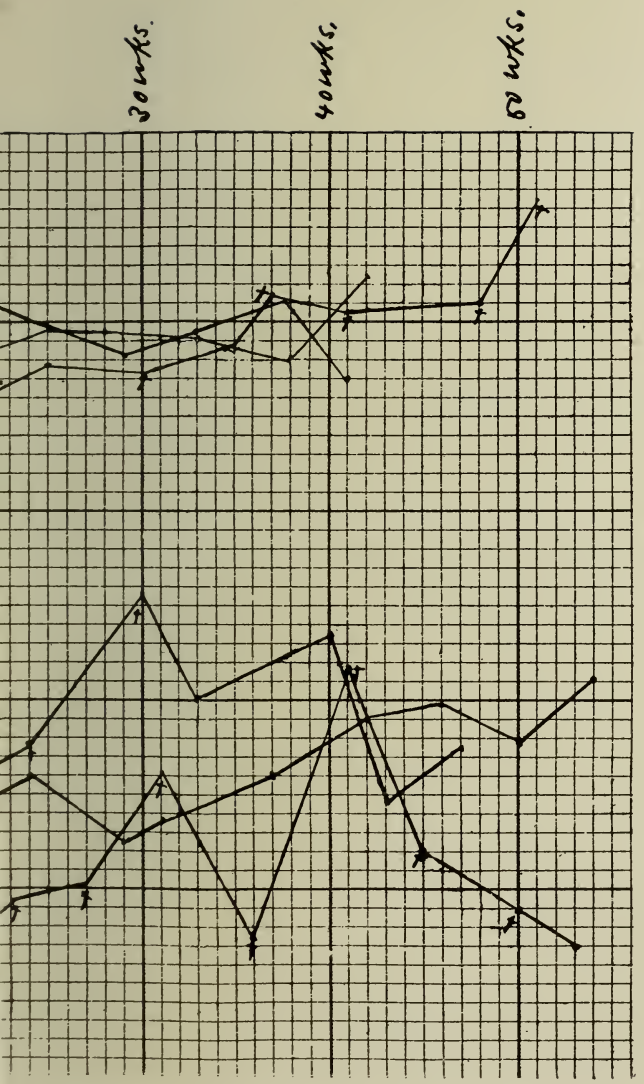

CHART II.

; the Variation in the Percentage of Butter Fat.

†Cow at pasture.

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Plate 2.—Showing the Va

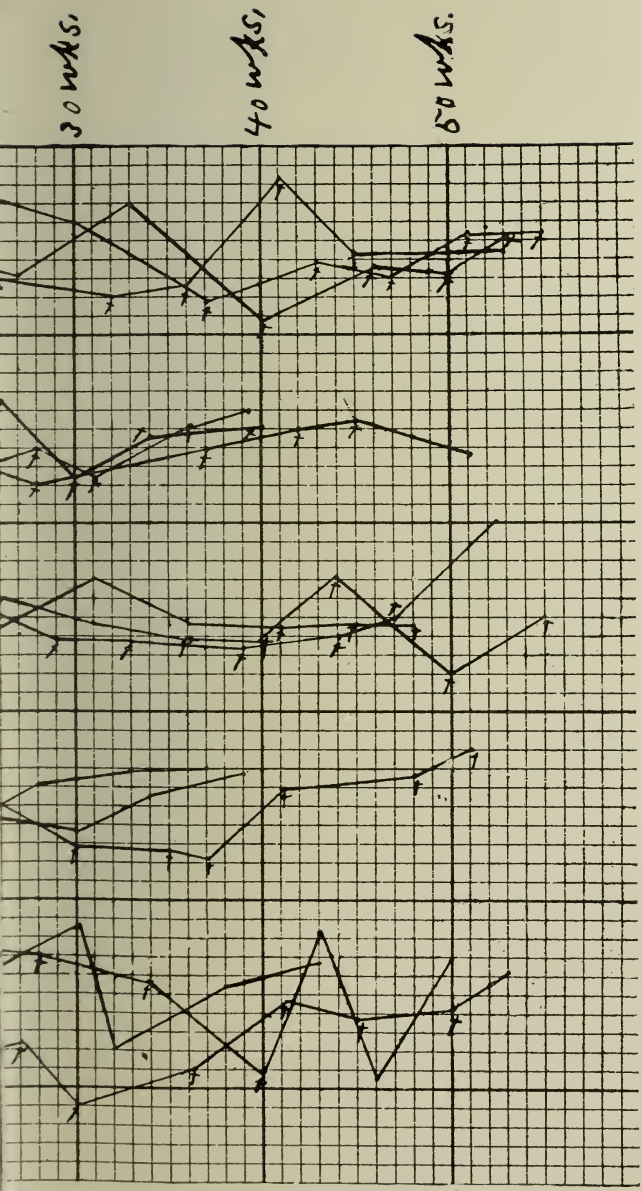

CHART III.

ıtion in the Percentage of Solids not Fat.

†Cow at pasture.

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some later period a lower fat percentage than during the first ten weeks. Four showed a very marked falling off in fat during the fifth, as compared with the fourth, period of ten weeks. Many attained their highest fat richness by the twentieth to thirtieth week, and then a falling off, to rise again just before going dry. Three cows showed little change in fat percentage during the entire period.

In the case of the solids-not-fat, most of the animals exhibited decided tendencies, either toward an increase or toward a decrease in these constituents in the early part of the lactation period, but about the thirtieth or fortieth week nearly all fell off sharply, and afterward exhibited more or less steady rise. This is well reflected in the averages earlier given for the entire group of animals.

The Effect of Change from Barn to Pasture: The second question relates to the effect of a change from barn to pasture, the common impression being that such change in feeding conditions is quite generally followed for several minutes by a depression in the several milk solids.

Of the fifteen cows considered in the above comparisons, twelve only were turned out to pasture, hence the subsequent observations relative to this question are based upon the composition of the milk from the smaller number.

In order to make a perfectly fair comparison of the fat percentages of the milk obtained under barn and pasture conditions, it would be necessary to select cows representing lactation periods distributed uniformly throughout the entire year. In other words, the commencement of the lactation periods of all of the same length should follow each other after equal intervals of time. In the twelve cases studied, however, rather more than a proportionate number date from the late fall and early winter, thus bringing the period of change to the pasture conditions to a time when the fat, as already seen, is near its maximum percentage.

The percentages of fat for the two periods together with the average for the entire time are as follows:

Average percentage of fat under barn conditions, 5.04.
Average percentage of fat under pasture conditions, 5.14.
Average percentage of fat under all conditions, 5.09.

These figures, together with a careful study of the diagrams for individual animals, indicate that the depression held to occur upon change to pasturage is by no means universal, is commonly of short duration, and is a much less influential cause of variation than is the advance in lactation.

Ayrshire Breed.

The records of 24 individual cows are given in the following tables:

TABLE XIX.—Breed, Ayrshire. Owner, J. R. Valentine, Bryn Mawr, Pa. Name, Ivan. (Register No. 14538.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
December, 1904, 2 days,	.....	4.05	13.15	9.10
January, 1905, 2 days,	32.5	4.00	12.93	8.93
February, 1905, 2 days,	31.0	4.30	12.91	8.61
March, 1905, 2 days,	31.0	4.45	13.09	8.64
April, 1905, 2 days,	30.0	4.15	12.48	8.33
May, 1905, 2 days,	34.5	4.40	13.91	9.51
June, 1905, 2 days,	33.0	4.30	13.41	9.11
July, 1905, 2 days,	34.5	3.80	13.17	9.37
August, 1905, 2 days,	36.0	5.00	15.00	10.00
October, 1905, 2 days,	29.0	4.00	12.05	8.05
November, 1905, 2 days,	29.5	4.00	12.18	8.18
December, 1905, 2 days,	32.0	3.60	12.32	8.72
January, 1906, 2 days,	32.0	3.70	12.44	8.74
February, 1906, 2 days,	33.0	3.65	12.67	9.02

TABLE XIX.—Breed, Ayrshire. Owner, J. R. Valentine, Bryn Mawr, Pa. Name, Ivan, 2nd. (Register No. 1725.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
December, 1904, 2 days,	.....	4.45	13.82	9.37
January, 1905, 2 days,	32.5	4.60	13.65	9.05
February, 1905, 2 days,	30.0	4.95	13.44	8.49
March, 1905, 2 days,	33.0	4.83	14.03	9.20
April, 1905, 2 days,	31.0	4.60	13.27	8.67
May, 1905, 2 days,	33.0	4.60	13.77	9.17
June, 1905, 2 days,	32.0	4.50	13.40	8.90
July, 1905, 2 days,	33.5	3.55	12.64	8.09
August, 1905, 2 days,	35.0	5.00	14.75	9.75
September, 1905, 2 days,	34.0	5.60	15.22	9.62
December, 1905, 2 days,	33.0	4.50	13.65	9.15
January, 1906, 2 days,	30.5	4.25	12.73	8.48
February, 1906, 2 days,	36.0	5.0	15.00	10.00
March, 1906, 2 days,	36.5	4.65	14.71	10.06

TABLE XX.—Breed, Ayrshire. Owner, J. R. Valentine, Bryn Mawr, Pa. Name, Oshawa Lady. (Register No. 16020.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
March, 1905, 2 days,	33.0	3.70	12.69	8.99
April, 1905, 2 days,	33.5	3.75	12.88	9.13
May, 1905, 2 days,	32.5	3.50	12.33	8.83
June, 1905, 2 days,	32.0	4.00	12.80	8.80
July, 1905, 2 days,	32.5	3.35	12.15	8.80
August, 1905, 2 days,	32.5	3.40	12.20	8.80
September, 1905, 2 days,	.....	3.90	.....	.....
October, 1905, 2 days,	30.5	3.60	11.95	8.35
November, 1905, 2 days,	33.5	4.30	13.54	9.24
December, 1905, 2 days,	33.0	4.20	13.29	9.09
January, 1906, 2 days,	31.5	4.30	13.04	8.74
February, 1906, 2 days,	33.0	4.65	13.83	9.18

TABLE XX.—Breed, Ayrshire. Owner, J. R. Valentine, Bryn Mawr, Pa. Name, Oshawa Lass of Highland. (Register No. 16534.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
March, 1905, 2 days,	33.0	3.75	12.75	9.00
April, 1905, 2 days,	33.5	3.65	12.76	9.11
May, 1905, 2 days,	30.5	3.90	12.32	8.42
June, 1905, 2 days,	32.0	3.75	12.50	8.75
July, 1905, 2 days,	32.5	3.20	11.97	8.77
August, 1905, 2 days,	32.5	3.80	12.69	8.89
September, 1905, 2 days,	31.0	3.70	12.91	9.21
October, 1905, 2 days,	33.0	2.10	10.77	8.67
November, 1905, 2 days,	33.5	4.70	14.02	9.32
December, 1905, 2 days,	32.0	4.70	13.64	8.94
January, 1906, 2 days,	31.0	4.80	13.51	8.71
February, 1906, 2 days,	35.0	5.20	14.99	9.79
March, 1906, 2 days,	33.5	5.20	14.62	9.42

TABLE XXI.—Breed, Ayrshire. Owner, J. R. Valentine, Bryn Mawr, Pa. Name, Rena Webb. (Register No. 12479.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
January, 1905, 2 days,	39.5	3.15	13.66	10.51
February, 1905, 2 days,	31.0	3.75	12.25	8.50
March, 1905, 2 days,	31.0	3.60	12.07	8.47
April, 1905, 2 days,	33.0	4.25	13.35	9.10
May, 1905, 2 days,	29.5	4.20	12.42	8.22
June, 1905, 2 days,	31.5	4.00	12.68	8.68
July, 1905, 2 days,	30.0	3.75	12.00	8.25
August, 1905, 2 days,	30.0	3.40	11.58	8.18
September, 1905, 2 days,	.....	4.00	.....	.....
October, 1905, 2 days,	30.0	4.30	12.66	8.36
November, 1905, 2 days,	28.5	4.10	12.05	7.95
December, 1905, 2 days,	33.0	4.55	13.71	9.16

TABLE XXI.—Breed, Ayrshire. Owner, J. R. Valentine, Bryn Mawr, Pa. Name, Keepsake. (Register No. 15913.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
April, 1905, 2 days,	33.0	3.95	12.99	9.04
May, 1905, 2 days,	31.5	3.70	12.32	8.62
June, 1905, 2 days,	32.5	3.85	12.65	8.80
July, 1905, 2 days,	31.5	4.35	13.11	8.76
August, 1905, 2 days,	31.0	4.00	12.55	8.55
September, 1905, 2 days,	30.0	3.90	12.23	8.33
October, 1905, 2 days,	.....	3.80	.....	.....
November, 1905, 2 days,	31.0	4.00	12.55	8.55
December, 1905, 2 days,	32.5	4.40	13.41	9.01
January, 1906, 2 days,	31.0	4.40	13.03	8.63
February, 1906, 2 days,	33.0	5.45	14.79	9.34
March, 1906, 2 days,	33.0	5.10	14.37	9.27

TABLE XXII.—Breed, Ayrshire. Owner, J. R. Valentine, Bryn Mawr, Pa. Name, Rena Ross. (Register No. 14539.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
December, 1904, 2 days,	.....	4.12	13.01	8.89
January, 1905, 2 days,	33.5	4.25	13.48	9.23
February, 1905, 2 days,	30.0	4.70	13.14	8.44
March, 1905, 2 days,	32.5	4.45	13.46	9.01
April, 1905, 2 days,	32.5	4.50	13.53	9.03
May, 1905, 2 days,	27.5	4.30	12.04	7.74
June, 1905, 2 days,	31.5	4.40	13.16	8.76
July, 1905, 2 days,	31.5	3.80	12.42	8.62
August, 1905, 2 days,	31.5	3.90	12.56	8.66
September, 1905, 2 days,	30.5	4.60	13.15	8.55
October, 1905, 2 days,	30.0	4.40	12.78	8.38
November, 1905, 2 days,	29.5	4.75	13.08	8.33

TABLE XXII.—Breed, Ayrshire. Owner, J. R. Valentine, Bryn Mawr, Pa. Name, Kitty K. (Register No. 12933.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
February, 1905, 2 days,	31.0	4.00	12.55	8.55
March, 1905, 2 days,	33.0	4.00	13.05	9.05
April, 1905,	34.0	3.55	12.76	9.21
May, 1905, 2 days,	33.5	4.10	13.30	9.20
June, 1905, 2 days,	34.0	4.05	13.06	9.01
July, 1905, 2 days,	32.5	3.80	12.69	8.89
August, 1905, 2 days,	32.0	3.40	12.08	8.68
September, 1905, 2 days,	32.5	4.20	13.17	8.97
October, 1905, 2 days,	32.0	4.30	13.16	8.86
November, 1905, 2 days,	30.5	4.35	12.85	8.50
December, 1905, 2 days,	34.0	4.00	13.30	9.30
January, 1906, 2 days,	35.0	4.00	13.55	9.55
February, 1906, 2 days,	34.0	4.45	13.78	9.33
March, 1906, 2 days,	33.5	4.20	13.42	9.22

TABLE XXIII.—Breed, Ayrshire. Owner, J. R. Valentine, Bryn Mawr, Pa. Name, Lady Bell 2nd. (Register No. 16535.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
March, 1905, 2 days,	33.0	4.00	13.05	9.05
April, 1905, 2 days,	33.5	4.10	13.30	9.20
May, 1905, 2 days,	27.0	3.80	11.31	7.51
June, 1905, 2 days,	34.5	4.00	13.43	9.43
July, 1905, 2 days,	33.5	3.40	12.46	9.06
August, 1905, 2 days,	33.0	3.60	12.57	8.97
September, 1905, 2 days,	33.0	4.20	13.23	9.08
October, 1905, 2 days,	32.0	4.40	13.53	9.13
November, 1905, 2 days,	34.5	5.55	15.29	9.74

TABLE XXIII.—Breed, Ayrshire. Owner, J. R. Valentine, Bryn Mawr, Pa. Name, Lady Bell of Highland. (Register No. 18246.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
January, 1905, 2 days,	34.5	3.90	13.31	9.41
February, 1905, 2 days,	32.0	3.70	12.44	8.74
March, 1905, 2 days,	33.0	4.20	13.29	9.09
April, 1905, 2 days,	33.0	4.20	13.29	9.09
May, 1905, 2 days,	33.0	4.40	13.53	9.13
June, 1905, 2 days,	32.0	3.75	12.50	8.85
July, 1905, 2 days,	32.5	3.85	12.75	8.90
August, 1905, 2 days,	33.0	3.50	12.45	8.95
September, 1905, 2 days,	31.0	3.65	12.13	8.48
October, 1905, 2 days,	30.0	1.80	9.66	7.86

TABLE XXIV.—Breed, Ayrshire. Owner, J. R. Valentine, Bryn Mawr, Pa. Name, Princess Beatrice 2nd. (Register No. 16533.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
December, 1904, 2 days,	.....	3.60	13.54	9.69
January, 1905, 2 days,	32.0	4.15	12.98	8.83
February, 1905, 2 days,	34.0	4.05	13.36	9.31
March, 1905, 2 days,	29.0	4.00	12.05	8.05
April, 1905, 2 days,	33.5	4.50	13.78	9.28
May, 1905, 2 days,	31.5	4.30	13.04	8.74
June, 1905, 2 days,	30.5	3.70	13.07	9.37
July, 1905, 2 days,	32.5	3.65	12.51	8.86
August, 1905, 2 days,	32.0	3.60	12.32	8.72
September, 1905, 2 days,	.....	4.05	.....	.....

TABLE XXIV.—Breed, Ayrshire. Owner, J. R. Valentine, Bryn Mawr, Pa. Name, Lady Bell 4th. (Register No. 17256.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
December, 1904, 2 days,	.....	4.00	13.11	9.11
January, 1905, 2 days,	35.0	4.20	13.79	9.59
February, 1905, 2 days,	33.0	4.50	13.65	9.15
March, 1905, 2 days,	33.5	4.40	13.66	9.26
April, 1905, 2 days,	33.0	4.70	13.89	9.19
May, 1905, 2 days,	33.5	4.30	13.54	9.24
June, 1905, 2 days,	33.0	4.45	13.59	9.14
July, 1905, 2 days,	33.5	4.00	13.18	9.18
August, 1905, 2 days,	33.0	4.60	13.77	9.17
September, 1905, 2 days,	32.0	5.00	14.00	9.00
October, 1905, 2 days,	32.0	5.00	14.00	9.00
December, 1905, 2 days,	33.0	5.40	14.73	9.33
January, 1906, 2 days,	32.5	4.30	13.29	9.99
February, 1906, 2 days,	34.0	4.30	13.66	9.36
March, 1906, 2 days,	35.5	3.95	13.62	9.67

TABLE XXV.—Breed, Ayrshire. Owner, Geo. H. McFadden, Bryn Mawr, Pa. Name, Mayflower of Monklance. (Register No. 15090).

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
April, 1905, 2 days,	32.5	3.35	12.15	8.80
May, 1905, 2 days,	34.5	4.10	13.55	9.45
June, 1905, 2 days,	30.0	4.10	12.92	8.82
July, 1905, 2 days,	30.5	4.00	12.43	8.43
August, 1905, 2 days,	31.0	4.50	13.15	9.65
September, 1905, 2 days,	30.0	4.50	12.90	8.40
October, 1905, 2 days,	31.5	4.50	13.28	8.78
November, 1905, 2 days,	31.5	4.30	13.04	8.74
December, 1905, 2 days,	33.5	4.40	13.66	9.26

TABLE XXV.—Breed, Ayrshire. Owner, Geo. H. McFadden, Bryn Mawr, Pa. Name, Bessie of Rosemont. (Register No. 17904.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
March, 1905, 2 days,	33.0	4.00	12.73	8.73
April, 1905, 2 days,	32.0	3.50	12.20	8.70
May, 1905, 2 days,	32.0	4.60	13.52	8.92
June, 1905, 2 days,	33.0	3.95	12.99	9.04
July, 1905, 2 days,	31.0	4.35	12.97	8.62
August, 1905, 2 days,	31.0	4.60	13.77	9.17
September, 1905, 2 days,	30.0	4.4	12.78	8.38
October, 1905, 2 days,	32.0	4.60	13.52	8.92
December, 1905, 2 days,	33.5	4.10	13.30	9.20
January, 1906, 2 days,	28.5	3.90	11.81	7.91
February, 1906, 2 days,	31.0	4.10	13.78	9.38
March, 1906, 2 days,	28.5	5.05	13.19	8.14

TABLE XXVI.—Breed, Ayrshire. Owner, Geo. H. McFadden, Bryn Mawr, Pa. Name, Brown Eyes of Knockdon. (Register No. 19216.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
March, 1905, 2 days,	34.5	3.80	13.19	9.39
April, 1905, 2 days,	32.0	2.95	11.54	8.59
May, 1905, 2 days,	32.0	3.70	12.44	8.74
June, 1905, 2 days,	31.0	4.15	12.73	8.58
July, 1905, 2 days,	31.5	3.55	12.14	8.59
August, 1905, 2 days,	32.0	3.70	12.44	8.74
September, 1905, 2 days,	30.5	4.10	12.55	8.45
October, 1905, 2 days,	32.5	4.20	13.16	8.96
November, 1905, 2 days,	32.5	4.40	13.41	9.01
February, 1906, 2 days,	34.0	4.00	13.30	9.30
March, 1906,	33.0	4.40	13.53	9.13

TABLE XXVI.—Breed, Ayrshire. Owner, Geo. H. McFadden, Bryn Mawr, Pa. Name, Queen of Barclay. (Register No. 15096.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
March, 1905, 2 days,	32.0	4.15	12.98	8.83
April, 1905, 2 days,	33.0	3.30	12.21	8.91
May, 1905, 2 days,	32.0	4.10	12.92	8.82
June, 1905, 2 days,	32.5	4.20	13.17	8.97
July, 1905, 2 days,	31.5	3.05	11.54	8.49
August, 1905, 2 days,	32.5	3.60	12.45	8.85
September, 1905, 2 days,	31.0	3.60	12.07	8.47
October, 1905, 2 days,	32.5	3.85	12.75	8.90
November, 1905, 2 days,	32.5	4.40	13.41	9.01
December, 1905, 2 days,	36.5	5.05	15.19	10.14

TABLE XXVII.—Breed, Ayrshire. Owner, Geo. H. McFadden, Bryn Mawr, Pa. Name, Beckey of Holchouse. (Register No. 17015.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
April, 1905, 2 days,	33.0	3.05	11.91	8.86
May, 1905, 2 days,	32.5	3.80	12.69	8.89
June, 1905, 2 days,	31.5	3.25	11.70	8.53
July, 1905, 2 days,	30.5	3.55	11.89	8.34
August, 1905, 2 days,	31.5	4.20	12.72	8.52
September, 1905, 2 days,	28.0	4.55	12.52	7.97
October, 1905, 2 days,	32.0	4.10	12.92	8.82
November, 1905, 2 days,	30.5	4.00	12.43	8.43
December, 1905, 2 days,	32.5	4.00	12.93	8.93
January, 1906, 2 days,	30.0	3.90	12.18	8.28
February, 1906, 2 days,	32.0	4.00	12.80	8.80
March, 1906, 2 days,	31.5	4.25	12.98	8.73

TABLE XXVII.—Breed, Ayrshire. Owner, Geo. H. McFadden, Bryn Mawr, Pa. Name, Finlyston, Maggie 3rd. (Register No. 19217.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
April, 1905, 2 days,	34.5	3.25	12.53	9.28
May, 1905, 2 days,	34.5	4.80	14.39	9.59
June, 1905, 2 days,	34.0	3.50	12.70	9.20
July, 1905, 2 days,	30.5	4.40	12.91	8.51
August, 1905, 2 days,	33.5	3.70	12.82	9.12
September, 1905, 2 days,	29.5	4.30	12.54	8.24
October, 1905, 2 days,	36.5	4.80	14.89	10.09
November, 1905, 2 days,	30.5	4.40	12.91	8.51
December, 1905, 2 days,	35.5	4.70	14.02	9.32
January, 1906, 2 days,	30.0	4.20	12.54	8.34
February, 1906, 2 days,	35.0	4.30	13.91	9.61
March, 1906, 2 days,	31.5	4.45	13.22	8.77

TABLE XXVIII.—Breed, Ayrshire. Owner, Geo. H. McFadden, Bryn Mawr, Pa. Name, Lilly 4th of Fairfield, Me. (Register No. 15579.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
March, 1905, 2 days,	35.0	3.55	13.01	94.6
April, 1905, 2 days,	33.0	3.30	12.21	8.91
May, 1905, 2 days,	32.0	4.00	12.80	8.80
June, 1905, 2 days,	31.5	3.90	12.56	8.66
July, 1905, 2 days,	31.0	3.55	11.89	8.34
August, 1905, 2 days,	31.5	3.40	11.96	8.56
September, 1905, 2 days,	30.5	3.90	12.31	8.41
October, 1905, 2 days,	32.5	3.95	12.87	8.92
November, 1905, 2 days,	32.5	4.20	13.17	8.97
December, 1905, 2 days,	35.5	4.60	14.40	9.80
January, 1906, 2 days,	32.5	4.70	13.77	9.07

TABLE XXVIII.—Breed, Ayrshire. Owner, Geo. H. McFadden, Bryn Mawr, Pa. Name, Dentz 9th, Auchenbain. (Register No. 15577.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
March, 1905, 2 days,	34.0	4.4	13.78	9.38
April, 1905, 2 days,	33.5	3.15	12.60	9.45
May, 1905, 2 days,	35.0	3.60	13.07	9.47
June, 1905, 2 days,	32.0	3.60	12.32	8.72
July, 1905, 2 days,	32.0	3.85	12.62	8.77
August, 1905, 2 days,	32.5	3.30	12.09	8.79
September, 1905, 2 days,	31.0	3.95	12.53	8.58
October, 1905, 2 days,	32.0	3.70	12.44	8.74
November, 1905, 2 days,	30.0	4.00	12.30	8.30
December, 1905, 2 days,	34.0	4.25	13.60	9.35
January, 1906, 2 days,	30.0	4.10	12.42	8.32
February, 1906, 2 days,	33.0	4.80	13.01	8.21
March, 1905, 2 days,	31.0	4.55	13.21	8.66

TABLE XXIX.—Breed, Ayrshire. Owner, Geo. H. McFadden, Bryn Mawr, Pa. Name, Clotilda of Rosemont. (Register No. 17893.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
December, 1904, 2 days,	.....	3.85	12.87	9.02
January, 1905, 2 days,	.....	.....	.....	.....
February, 1905, 2 days,	35.0	4.0	13.55	9.55
March, 1905, 2 days,	34.0	3.8	13.06	9.26
April, 1905, 2 days,	35.0	3.5	12.95	9.45
May, 1905, 2 days,	34.0	4.0	13.50	9.50
June, 1905, 2 days,	33.0	3.45	12.49	9.04
July, 1905, 2 days,	31.5	4.0	12.68	8.68
August, 1905, 2 days,	32.5	3.1	11.85	8.75
September, 1905, 2 days,	31.0	4.2	12.80	8.60
October, 1905, 2 days,	33.0	3.65	12.63	8.98

TABLE XXIX.—Breed, Ayrshire. Owner, Geo. H. McFadden, Bryn Mawr, Pa. Name, Daisy of Rosemont. (Register No. 17011.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
April, 1905, 2 days,	34	3.6	12.82	9.22
May, 1905, 2 days,	33	3.9	12.93	9.03
June, 1905, 2 days,	31	3.45	11.89	8.44
July, 1905, 2 days,	30	4.35	12.72	8.37
August, 1905, 2 days,	31	3.6	12.07	8.47

TABLE XXX.—Breed, Ayrshire. Owner, Geo. H. McFadden, Bryn Mawr, Pa. Name, Letta Lind of Radnor. (Register No. 17892.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
December, 1904, 2 days,	33.0	4.05	13.11	9.06
January, 1905, 2 days,	.....	.....	.....	.....
February, 1905, 2 days,	35.5	4.40	14.16	9.76
March, 1905, 2 days,	36.0	4.30	14.16	9.86
April, 1905, 2 days,	34.0	4.75	14.50	9.75
May, 1905, 2 days,	32.0	4.60	13.52	8.92
June, 1905, 2 days,	32.0	4.10	12.92	8.82
July, 1905, 2 days,	32.5	4.30	12.43	8.13
August, 1905, 2 days,	32.0	5.00	14.00	9.00
September, 1905, 2 days,	30.5	4.65	13.21	8.56
October, 1905, 2 days,	32.0	5.45	14.54	9.09

TABLE XXX.—Breed, Ayrshire. Owner, Geo. H. McFadden, Bryn Mawr, Pa. Name, Butter Cup of Rosemont. (Register No. 17900.)

Time of Sampling.	Average lactometer reading.	Average Percentage Composition.		
		Fat.	Total solids.	Solids-not-fat.
December, 1904, 2 days,	32.0	3.9	12.68	8.78
January, 1905, 2 days,	.....	.....	.....	.....
February, 1905, 2 days,	34.0	4.1	13.42	9.32
March, 1905, 2 days,	35.0	3.5	12.95	9.45
April, 1905, 2 days,	34.0	3.5	12.70	9.20
May, 1905, 2 days,	35.0	4.2	13.79	9.59
June, 1905, 2 days,	32.0	4.1	12.92	8.82
July, 1905, 2 days,	32.5	4.4	13.41	9.01
August, 1905, 2 days,	35.5	4.0	13.68	9.68
September, 1905, 2 days,	33.5	5.85	15.40	9.55
October, 1905, 2 days,	.....	4.60	.....	.....
December, 1905, 2 days,	32.5	3.3	12.09	8.79
January, 1906, 2 days,	27.5	4.7	12.52	7.82
February, 1906, 2 days,	34.0	3.6	12.82	9.22
March, 1906, 2 days,	29.0	3.65	11.63	7.98
April, 1906, 2 days,	32.0	3.8	12.56	8.76

Holstein-Friesian Breed.

Week-long records for ten individuals of this breed follow:

TABLE XXXI.—Breed, Holstein-Friesian. Owner, J. N. Conyngham, Wilkes-Barre. Name, Uander Lei Suberb 2d. (Register No. 76137.)

Time of Sampling.	Average percentage of fat.	Milk yield. Lbs.	Fat yields. Lbs.
April 24, 1905,	3.58	76.875	2.753
April 25, 1905,	3.32	81.375	2.704
April 26, 1905,	3.65	80.500	2.939
April 27, 1905,	3.35	80.375	2.704
April 28, 1905,	3.60	82.750	2.991
April 29, 1905,	3.42	83.375	2.863
April 30, 1905,	3.20	86.375	2.767
For the seven days,	3.44	571.625	19.721

TABLE XXXI.—Breed, Holstein-Friesian. Owner, J. N. Conyngham, Wilkes-Barre. Name, Hillside Rebecca. (Register No. 75642.)

Time of Sampling.	Average percentage of fat.	Milk yield. Lbs.	Fat yields. Lbs.
April 24, 1905,	3.55	61.625	2.200
April 25, 1905,	3.82	56.750	2.151
April 26, 1905,	3.35	65.125	2.180
April 27, 1905,	3.28	64.375	2.110
April 28, 1905,	3.33	63.500	2.116
April 29, 1905,	3.32	62.375	2.068
April 30, 1905,	3.27	65.125	2.128
For the seven days,	3.47	438.875	14.953

TABLE XXXII.—Breed, Holstein-Friesian. Owner, J. N. Conyngham, Wilkes-Barre, Pa. Name, Hillside Lita. (Register No. 76139.)

Time of Sampling.	Average percentage of fat.	Milk yield. Lbs.	Fat yields. Lbs.
April 24, 1905,	3.67	74.000	2.714
April 25, 1905,	3.67	74.625	2.736
April 26, 1905,	3.73	78.375	2.926
April 27, 1905,	3.63	78.625	2.856
April 28, 1905,	3.45	81.250	2.800
April 29, 1905,	3.50	82.125	2.870
April 30, 1905,	3.40	85.375	2.904
For the seven days,	3.57	554.375	19.806

TABLE XXXII.—Breed, Holstein-Friesian. Owner, J. N. Conyngham, Wilkes-Barre, Pa. Name, Hillside Molly. (Register No. 76146.)

Time of Sampling.	Average percentage of fat.	Milk yield. Lbs.	Fat yields. Lbs.
April 24, 1905,	3.37	55.875	1.879
April 25, 1905,	3.47	59.000	2.045
April 26, 1905,	3.18	58.250	1.853
April 27, 1905,	3.47	60.000	2.082
April 28, 1905,	3.42	59.625	2.040
April 29, 1905,	3.48	60.625	2.111
April 30, 1905,	3.42	60.250	2.130
For the seven days,	3.42	413.625	14.140

TABLE XXXII.—Breed, Holstein-Friesian. Owner, J. N. Conyngham, Wilkes-Barre, Pa. Name, Hillside Mabel. (Register No. 75641.)

Time of Sampling.	Average percentage of fat.	Milk yield. Lbs.	Fat yields. Lbs.
April 24, 1905,	3.17	58.750	1.859
April 25, 1905,	3.60	58.875	2.119
April 26, 1905,	3.37	56.375	1.903
April 27, 1905,	3.78	51.250	1.937
April 28, 1905,	3.43	50.250	1.727
April 29, 1905,	3.47	51.375	1.794
April 30, 1905,	3.13	55.625	1.745
For the seven days,	3.42	382.500	13.084

TABLE XXXIII.—Breed, Holstein-Friesian. Owner, G. N. Carpenter, Wilkes-Barre, Pa. Name, Klaasje Clotilda. (Register No. 43204.)

Time of Sampling.	Average percentage of fat.	Milk yield. Lbs.	Fat yields. Lbs.
March 15, 1905,	3.45	54.0	1.863
March 16, 1905,	3.71	57.5	2.135
March 17, 1905,	3.79	57.7	2.186
March 18, 1905,	4.00	54.5	2.177
March 19, 1905,	3.77	55.6	2.094
March 20, 1905,	3.56	52.7	1.877
March 21, 1905,	3.51	56.3	1.979
For the seven days,	3.69	388.3	14.311

TABLE XXXIII.—Breed, Holstein-Friesian. Owner, G. N. Carpenter, Wilkes-Barre, Pa. Name, Troup C. (Register No. 56212.)

Time of Sampling.	Average percentage of fat.	Milk yield. Lbs.	Fat yields. Lbs.
March 15, 1905,	3.37	49.1	1.650
March 16, 1905,	3.32	51.2	1.696
March 17, 1905,	3.60	50.5	1.817
March 18, 1905,	3.65	49.9	1.819
March 19, 1905,	3.53	49.5	1.748
March 20, 1905,	3.42	48.5	1.572
March 21, 1905,	3.35	51.6	1.726
For the seven days,	3.43	350.3	12.028

TABLE XXXIII.—Breed, Holstein Friesian. Owner, G. N. Carpenter, Wilkes-Barre, Pa. Name, Troup Princess. (Register No. 60274.)

Time of Sampling.	Average percentage of fat.	Milk yield. Lbs.	Fat yields. Lbs.
March 15, 1905,	3.03	23.7	.717
March 16, 1905,	3.13	23.2	.724
March 17, 1905,	3.40	23.2	.787
March 18, 1905,	3.33	24.3	.817
March 19, 1905,	3.33	23.8	.792
March 20, 1905,	3.30	23.3	.768
March 21, 1905,	3.27	22.9	.747
For the seven days,	3.25	164.4	5.352

TABLE XXXIV.—Breed, Holstein-Friesian. Owner, G. N. Carpenter, Wilkes-Barre, Pa. Name, Dijkstra Beauty. (Register No. 51825.)

Time of Sampling.	Average percentage of fat.	Milk yield. Lbs.	Fat yields. Lbs.
September 10, 1905,	4.92	40.7	2.000
September 11, 1905,	5.10	46.7	2.367
September 12, 1905,	4.91	46.3	2.277
September 13, 1905,	4.69	42.4	1.995
September 14, 1905,	4.64	41.7	1.934
September 15, 1905,	4.33	41.2	1.788
September 16, 1905,	4.53	38.4	1.750
For the seven days,	4.75	297.4	14.111

TABLE XXXIV.—Breed. Holstein-Friesian. Owner, G. N. Carpenter, Wilkes-Barre, Pa. Name, Arlep Clothilde. (Register No. 51824.)

Time of Sampling.	Average percentage of fat.	Milk yield. Lbs.	Fat yields. Lbs.
September 11, 1905,	3.30	50.6	1.667
September 12, 1905,	3.28	56.2	1.838
September 13, 1905,	3.25	52.4	1.699
September 14, 1905,	3.41	51.5	1.763
September 15, 1905,	3.20	53.2	1.719
September 16, 1905,	3.08	55.8	1.679
September 17, 1905,	3.33	48.7	1.697
For the seven days,	3.27	368.4	12.062

There is a third question upon which the foregoing data throw some light, namely, do animals giving rich milk tend to yield a more variable product than animals giving poorer milk?

To group the facts bearing upon this question for convenient consideration, the following tables have been arranged, showing the average amounts of fat and solids-not-fat, and the range of variation of these components in the milk of individual cows through the entire period represented. It must be recalled that the period of representation for the Holstein-Friesian breed was only a week in each case. The extent of varieties observed in case of this breed is not fairly comparable with those exhibited for much larger periods by the Guernsey and Ayrshire breeds; even in case of the latter breed, the samples, representing daily milkings, taken at considerable intervals, do not certainly exhibit the extremes of variation in the milk for the entire lactation periods.

Variations in Composition of Milk from Sugar Corn.

Guernsey.	Fat.		Solids-not-Fat.	
	Average. Per cent.	Range. Per cent.	Average. Per cent.	Range. Per cent.
Auto-Leight,	5.65	1.71	9.70	.95
Sylphama,	4.45	.63	9.44	1.28
Darthea,	5.17	2.26	9.54	1.39
Madras,	5.65	.81	9.75	1.57
Lady Irwin of Highland,	5.62	1.61	9.48	.59
Sweet Clover,	4.96	2.74	9.39	.79
Moverina,	5.23	1.36	9.79	1.21
Alta's Jewel,	5.04	1.05	6.98	1.14
Vega 2d,	4.50	1.87	9.54	.90
Dorothy Thorn,	4.62	1.08	9.73	.59
Alta's Pearl,	4.76	2.05	9.61	.98
Juliet of Orange,	4.66	1.05	9.73	1.11
Young Polly Vrangve,	6.26	2.86	9.63	1.58
Estella Trink,	5.82	2.72	9.66	1.31
Alta's Jem,	4.39	4.33	9.21	1.44
Lady Trowbridge,	4.57	1.08	9.63	.75
Beauty of Orange,	5.08	3.23	9.64	1.24
Ecstasy of Orange,	5.78	3.29	9.82	1.53
Average,	5.13	1.99	9.61	1.14
Ayrshire.				
Ivan,	4.17	.85	8.88	1.95
Ivan 2d,	4.65	2.05	9.14	1.97
Oshawa Lady,	3.89	1.30	8.90	.89
Oshawa Lady of Highland,	4.03	3.10	9.08	1.37
Rena Webb,	3.92	1.40	8.67	2.56
Keepsake,	4.41	1.75	8.81	1.01
Rena Ross,	4.35	.95	8.64	.90
Kitty K,	4.03	1.05	9.02	1.05
Lady Belle 2d,	4.12	1.95	9.02	2.23
Lady Belle of Highland,	3.70	2.60	8.85	1.55
Princess Beatrice 2d,	3.96	.90	8.98	1.64
Lady Belle 4th,	4.47	1.45	9.29	.99
Mayflower of Monkland,	4.20	1.15	8.92	1.25
Bessie of Rosemont,	4.28	1.55	8.76	1.29
Brown Eyes of Knockdon,	3.90	1.45	8.86	.94
Queen of Barclay,	3.93	2.00	8.94	1.67
Beckey of Holehouse,	3.80	1.50	8.59	.96
Finlayston Maggie,	4.22	1.55	9.05	1.85
Lilly 4th of Fairfield, Me.,	3.91	1.40	8.90	1.46
Dentz 9th of Auchenbain,	3.94	1.65	8.83	1.26
Clotilda of Rosemont,	3.76	1.10	9.08	.95
Daisy of Rosemont,	3.80	.90	8.71	.85
Letta Lind of Radnor,	4.56	1.40	9.10	1.73
Butter-Cup of Rosemont,	4.08	2.35	9.00	1.86
Average,	4.09	1.56	8.92	1.43

Holstein-Friesian.	Fat.	
	Average. Per cent.	Range. Per cent.
Uander Lei Suberb 2d,	3.44	.45
Hillside Rebecca,	3.47	.55
Hillside Leita,	3.57	.33
Hillside Mabel,	3.42	.65
Hillside Molly,	3.42	.30
Klaasje Clotilda,	3.69	.55
Troup C,	3.43	.28
Troup Princess,	3.25	.37
Dijkstra Beauty,	4.75	.77
Arlep Clothilda,	3.27	.33
Average,	3.57	.46

These tables show great differences in individuals, differences strikingly shown in the diagrams earlier given.

With respect to the Guernsey breed, the average range of variation of the fat percentage was 1.99 per cent., about 38.8 per cent. of the average fat. But the range shown by Machas was only 81 per cent., corresponding to about 14.3 per cent. of her fat average; while Alta's Jem showed a variation of 4.33 per cent., an amount equivalent to 100 per cent. of her fat averages.

The average range of variation in solids-not-fat was 11.9 per cent. of the average solids-not-fats. The lowest proportional variation was about 6 per cent. of her average solids-not-fat in the case of Lady Irwin of Highland; the highest, 16.4 per cent. in the case of Young Polly Vrangve.

With respect to the Ayrshire breed: It is notable that the milk given by the individuals is by no means low in fat, the average being but one per cent. less than that of the selected Guernsey animals tested. The average range of fat variation, 1.56 per cent., is 38.1 per cent. of the average fat richness, 4.09 per cent. In the case of Ivan, the range in fat was almost 20.3 per cent. of her fat average; in the case of Oshawa Lass of Highland, about 76.9 per cent. of her fat average.

The average solids-not-fat for certain individuals of this breed are surprisingly low; in view, however, of the method of preservation earlier mentioned as that employed for the Ayrshire samples, the data for solids-not-fat are not certainly trustworthy, and warrant no further comment.

The week-long records for the Holstein-Friesian cows show a range of variation for the fat of .46 per cent., equivalent to 12.9 per cent. of the average fat content; the ranges for individual cows varied from 8.2 to 19 per cent. of the corresponding averages.

From these comparisons it appears that while the breed giving richer milk shows a great absolute range of variation in the fat content of the milk, the range is no greater in proportion to the average richness of the milk in the case of the average high-class Guernsey than in that of the average high-class Ayrshire.

NOTES ON THE DIGESTIBILITY OF PENTOSANS.

M. S. McDOWELL.

The methods of analysis in the case of ordinary feeding stuffs have this defect: that only a few of the many individual constituents present are determined.

For the determination of feeding values an estimate of moisture, fat, protein, ash and fiber is all that is usually made, the remainder being derived by difference and classified under the head of nitrogen-free extract; notwithstanding the fact that the carbohydrates (chiefly starch and sugar) which are known to be digestible and to have a distinct nutritive value in the animal body form a large proportion of many feeds. In recent years methods have been adopted whereby many of these groups can be separately determined. Among these are the pentosans. This group of bodies is usually classified along with starch, sugars, etc., as nitrogen-free extract, although a portion of the pentosans is included with the crude fiber, as the conditions under which the latter is determined do not render all the pentosans soluble. The name "pentosans" is applied to them from the fact that hydrolytic action results in the formation of sugars containing five atoms of carbon, whereas similar action in the case of starch and cellulose results in the formation of sugars having six carbon atoms. Pentosans, therefore, bear the same relation to the pentose sugars as starch and cellulose to the hexose sugar, dextrose. Arabinose and xylose are the two best known sugars from the parent pentosan. They are insoluble and aid cellulose in giving form and structure to the plant. Action of dilute acids and alkalies breaks them down into soluble bodies, while true cellulose remains insoluble. They are found in all woody matters, as in wood, leaves, roots, stems, chaff, seed coats, etc., as well as in a great variety of plant juices. The distinctive characteristic of this class of bodies is that they yield an aldehyde, furfurol, on distilation with dilute acid.

The value of any feeding stuff depends upon the proportion of its components which can be digested by the animal, as well as upon the total amounts of these ingredients present.

The digestibility and food value of the carbohydrates, starch and sugar, are well known and have already been referred to.

Crude fiber is also broken down and absorbed to a considerable extent in the course of digestion. It is probable, however, that the solubility in this case is the result of action of a ferment in the fiber itself or of organized ferments in the digestive tract, rather than to the action of the fluids secreted during digestion.

The pentosans are apparently digestible, being largely absorbed, although their exact nutritive value is not known. The data presented herewith on the digestibility of the pentosans were obtained

in connection with the Respiration Calorimeter work carried on by the Division of Animal Nutrition in the course of the past three years.

In the experiments of the first two years only one steer was employed, while in the third year two animals were employed. In 1902-3 the ration consisted of clover hay and corn meal; in 1903-4 of clover hay alone; and in 1904-5 of timothy hay and bran. The method employed in the determination of the pentosans is that adopted by the Association of Official Agricultural Chemists, namely, distilling with hydrochloric acid of 1.06 sp. gr. and precipitating the furfurol in the distillate with phloroglucin, the formula as worked out by Kröber being used for calculating from the weights of precipitate the corresponding percentage of pentosans.

The following figures show the amounts of food consumed and feces excreted together with the amount and digestibility of the pentosans in the several foods:

Clover Hay and Corn Meal.

	Hay consumed and feces excreted. Dry matter. Grams.	Pentosans. Per cent.	Pentosans. Grams.
Period I.			
Hay,	44,589.8	13.76	6,146
Feces,	18,223.3	15.32	2,792
Digested,			3,354
Per cent. digested,			54.57
Period II.			
Hay,	31,438.9	13.71	4,310
Feces,	12,669.8	14.98	1,899
Digested,			2,411
Per cent. digested,			55.94
Period III.			
Hay,	31,627.6	13.22	4,181
Corn meal,	7,347.4	5.62	413
Total,			4,594
Feces,	13,675	13.54	1,852
Digested,			2,742
Less pentosans digested from hay,			2,310
Digested from corn meal,			432
Per cent. digested from corn meal,			104.6
Period IV.			
Hay,	31,864	12.69	4,044
Corn meal,	34,508	6.05	2,088
Total,			6,132
Feces,	15,773.5	13.47	2,125
Digested,			4,007
Less pentosans digested from hay,			2,235
Digested from corn meal,			1,772
Per cent. digested from corn meal,			84.86

Clover Hay.

	Hay consumed and forces excreted. Dry matter. Grams.	Pentosans. Per cent.	Pentosans. Grams.
Period I.			
Hay,	33,921	14.05	4,765.9
Feces,	11,327	13.63	1,543.8
Digested,			3,222.1
Per cent. digested,			67.61
Period II.			
Hay,	50,253	14.14	7,105.7
Feces,	19,401	13.79	2,675.4
Digested,			4,430.3
Per cent. digested,			62.35
Period III.			
Hay,	41,391	14.57	6,030.6
Feces,	16,271	13.61	2,214.5
Digested,			3,816.1
Per cent. digested,			63.28

Timothy Hay and Bran.

	Hay consumed and feces excreted. Dry matter. Grams.	Pentosans. Per cent.	Pentosans. Grams.
Steer "a."			
Hay,	21,150	24.84	5,254
Feces,	9,775	23.53	2,300
Digested,			2,954
Per cent. digested,			56.22
Period III—Steer "b."			
Hay,	18,750	25.01	4,689
Feces,	8,454	21.91	1,852
Digested,			2,837
Per cent. digested,			60.50
Steer "a."			
Hay,	36,638	23.95	8,775
Feces,	17,918	23.27	4,170
Digested,			4,605
Per cent. digested,			52.47
Period IV—Steer "b."			
Hay,	27,295	24.91	6,799
Feces,	12,462	22.07	2,750
Digested,			4,049
Per cent. digested,			59.55
Steer "a."			
Hay,	37,155	25.29	9,396
Bran,	26,111	26.00	6,789
Total,			16,185
Feces,	26,806	25.81	6,919
Digested,			9,266
Less pentosan digested from hay,			5,106
Digested from bran,			4,160
Per cent. digested from bran,			61.27
Period I—Steer "b."			
Hay,	18,472	24.97	4,612
Bran,	10,914	27.00	2,947
Total,			7,559
Feces,	11,816	24.51	2,896
Digested,			4,663
Less pentosan digested from hay,			2,768
Digested from bran,			1,895
Per cent. digested from bran,			64.30
Steer "a."			
Hay,	22,592	25.01	5,650
Bran,	28,088	26.98	7,577
Total,			13,227
Feces,	19,045	26.02	4,956
Digested,			8,271
Less pentosan digested from hay,			3,071
Digested from bran,			5,200
Per cent. digested from bran,			68.63
Period II—Steer "b."			
Hay,	20,140	24.36	4,906
Bran,	19,600	26.04	5,104
Total,			10,010
Feces,	14,744	23.21	3,422
Digested,			6,588
Less pentosan digested from hay,			2,945
Digested from bran,			3,643
Per cent. digested from bran,			71.37

The above data for clover hay alone show an average digestibility of 60.75 per cent., and for timothy hay alone 57.18 per cent. which is in accord with that found by both Stone and Lindsay for similar feeds. The figures in case of corn meal illustrate the well known fact that associated material greatly affects the digestibility and that the determination of the digestibility of the minor constituents of grain feed is difficult.

In the present instance, the effect of the corn meal has apparently been to increase the digestibility of the hay. The corn meal, containing a comparatively small amount of pentosan, when fed in small quantities especially emphasizes this fact. In Period IV where the corn meal is fed in larger quantities, this effect is not so marked and the results in the latter case probably represent more nearly the digestibility of the meal.

It may be interesting in this connection to compare the computed digestibility of the other components of the corn meal in Periods III and IV as given in Bulletin 74, Bureau of Animal Industry, U. S. Department of Agriculture, to which has been appended that of the pentosans as shown in the preceding tables.

	Period III.	Period IV.
Dry matter,	87.34	91.50
Ash,	.....	18.40
Organic Matter,	89.16	92.60
Total protein,	85.23	62.30
Proteids,	80.14	66.43
Crude fiber,	.....	32.40
Nitrogen free extract,	98.11	97.75
Ether extract,	103.72	95.74
Energy,	85.46	90.81
Pentosans,	104.60	84.86

What is true of the pentosans is also true of some of the other constituents and the same discrepancy appears as between Periods III and IV.

In case of the bran, the average digestibility is 66.39 per cent. Stone,* in case of corn meal and bran fed to rabbits, and of hay† and different grasses fed to sheep, found an average digestibility of 60 per cent. Lindsay,‡ using similar feeds with sheep, confirms these results and, in case of more concentrated feeds, finds the pentosans as digestible as any of the other groups of fodder constituents.

While the pentosans are apparently as digestible as the other plant substances, it must be borne in mind that apparent digestibility does not necessarily mean food value.

*Am. Chem. Jour. 14-9.
†Agr. Sci. 5-6.
‡Mass. State Rpt. 1904, 175.

METEOROLOGY.

BY N. C. HAMNER AND F. W. CHRISTENSEN.

It is universally known that the climatic relations of any locality or season determine chiefly the success of the crops raised; but very little is known concerning the exact relation of climatic differences between several locations or seasons to the success or failure of any crop, except in the most general way. It is very desirable, therefore, to fix accurately the climatic conditions under which field investigations are carried on, and to determine, if possible, to what extent and in what way a given change in any of the conditions that go to make up the weather affects the various plants submitted to test.

The work of the past year has been chiefly a continuation of the work of the preceding years, including observations of the kind usually made by the United States Weather Service upon atmospheric phenomena and upon the amount of sunshine.

The results of the observations upon atmospheric phenomena and the amount of sunshine have been reported regularly to the United States Weather Bureau.

ATMOSPHERIC METEOROLOGY.

The latitude of the Station is about 40 degrees 55 minutes N., and the longitude about 77 degrees 51 minutes W. The altitude of the mercury level of the barometer is about 1,217 feet above sea level. The thermometer shelter is sixty feet northwest of the Station office and stands sixteen feet above the ground.

The apparatus used consists of a standard mercurial barometer reading to 0.001 inch; dry and wet bulb and maximum and minimum thermometers by Green; standard 8-inch rain gauge, standing two feet above the ground level, and weather vane.

Meteorological Summary for 1905. Monthly Means, etc. (Figures within ( ) Indicate Days of the Month.)

	January.		February.		March.		April.		May.		June.	
Atmospheric Pressure.												
Monthly mean,		30.168		30.208		30.144		29.855		29.985		29.985
Highest,	(11)	30.695	(19)	30.696	(2)	31.211	(23)	30.457	(5)	30.236	(30)	31.056
Lowest,	(22)	29.265	(13)	29.625	(18)	29.689	(27)	29.543	(17)	29.686	(26)	29.629
Monthly range,		1.430		1.071		1.522		.914		.550		1.427
Temperature (Deg. Fahr.)												
Monthly mean,		22.3		19.4		38.3		45.2		58.5		66.5
Maximum,	(1)	49.0	(21)	44.0	(29)	79.0	(27,28)	74.0	(4)	85.0	(19)	89.0
Mean maximum,		28.9		27.1		47.4		55.9		68.2		75.0
Minimum,	(26)	—5.0	(14)	—11.0	(2, 5)	10.0	(17)	18.0	(21)	34.0	(3,9)	43.0
Mean minimum,		15.6		11.8		29.1		34.4		48.8		58.0
Monthly range,		54.0		55.0		69.0		56.0		51.0		46.0
Daily Range.												
Greatest,	(12)	23.0	(14)	29.0	(16)	34.0	(4)	45.0	(8)	34.0	(9)	31.0
Least,	(2)	3.0	(7)	6.0	(21)	4.0	(11)	7.0	(26)	6.0	(7)	5.0
Mean,		12.9		15.8		18.4		21.3		19.4		17.0
Humidity.												
Mean relative hum., per cent.,		96.7		98.1		87.7		72.8		73.6		81.1
Mean dew point (Deg. Fahr.),		19.4		16.9		33.2		37.0		49.2		59.9
Precipitation.												
Total in inches,		3.19		1.23		3.92		2.49		3.34		3.98
Snow fall in inches,		16.20		12.30		7.00		.90				
Greatest daily precipitation,	(7)	.81	(12)	.42	(21)	1.33	(10)	.67	(26)	1.03	(6)	.81
Number of days on which .01 inch or more of rain fell,		13		8		12		13		12		15
Cloudiness.												
Mean percentage,		77		49.5		45.5		42		49		55
Number of days on which cloudiness averaged 80 per cent. or more,		15		8		9		5		10		9
Wind.												
Prevailing direction,		W		W		N		W		W		N
Miscellaneous Data.												
Dates of thunderstorms,						(26)	(10)		(6,11,17)		(4,6,7,19)	
Dates of hail,							(10)					
Dates of frost,									(21,24)			
Dates of halos, lunar,				(14,16,19)			(12)					

Meteorological Summary for 1905—Continued.

	July.		August.		September.		October.		November.		December.	
Atmospheric Pressure.												
Monthly mean,	.....	29.958	.....	29.974	.....	30.050	.....	30.085	.....	30.060	.....	30.126
Highest,	(10)	31.011	(28)	30.133	(14)	30.319	(29)	30.529	(30)	30.717	(28)	31.222
Lowest,	(30)	29.625	.....	29.654	(11)	29.850	(11)	29.680	(16)	29.474	(29)	29.460
Monthly range,	.....	1.386	(15)	.479	.....	1.469	.....	.849	.....	1.243	.....	1.762
Temperature.												
Monthly mean,	.....	70.0	.....	67.2	.....	63.0	.....	51.1	.....	36.9	.....	32.3
Maximum,	(17,18)	88.0	(24)	86.0	(19)	84.0	(1)	82.0	(12)	58.0	(8)	51.0
Mean maximum,	.....	77.7	.....	76.4	.....	72.6	.....	60.6	.....	44.7	.....	39.0
Minimum,	.....	51.0	(28)	45.0	(26)	34.0	(30)	26.0	(14)	13.0	(1)	9.0
Mean minimum,	.....	62.4	.....	58.0	.....	53.3	.....	41.6	.....	29.0	.....	25.5
Monthly range,	.....	37.0	.....	41.0	.....	50.0	.....	56.0	.....	45.0	.....	42.0
Daily Range.												
Greatest,	(10,16)	25.0	(28)	29.0	(26)	39.0	(8)	33.0	(22)	32.0	(17)	31.0
Least,	(4)	5.0	(14)	4.0	(15)	5.0	(31)	3.0	(9)	4.0	(19,20)	3.0
Mean,	.....	15.3	.....	18.4	.....	19.3	.....	18.1	.....	15.7	.....	13.4
Humidity.												
Mean relative hum., per cent.,	.....	80.4	.....	82.9	.....	79.3	.....	79.3	.....	80.2	.....	88.3
Mean dew point (Deg. Fahr.),	.....	63.5	.....	61.5	.....	54.9	.....	44.2	.....	29.5	.....	28.1
Precipitation.												
Total in inches,	.....	3.86	.....	4.28	.....	1.88	.....	2.83	.....	2.65	.....	3.43
Snowfall in inches,	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.00	.....	.80
Greatest daily precipitation,	(29)	.51	(12)	1.17	(11)	.74	(2)	1.09	(29)	.93	.....	1.21
Number of days on which .01 inch or more of rain fell,	.....	15	.....	11	.....	6	.....	5	.....	14	.....	9
Cloudiness.												
Mean percentage,	.....	47.5	.....	38.5	.....	29.0	.....	38.4	.....	48.0	.....	60.2
Number of days on which cloudiness averaged 80 per cent. or more,	.....	7	.....	1	.....	6	.....	10	.....	10	.....	15
Wind.												
Prevailing direction,	.....	S	.....	N & W	.....	W	.....	W	.....	W & NW	.....	W
Miscellaneous Data.												
Dates of thunderstorms,	(2,6,7,8,13,	14,23,29)	(4,6,22,24,	30)	.....	.....	.....	.....	.....	.....	.....	.....
Dates of hail,	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Dates of frost,	.....	.....	.....	.....	.....	(26)	(17,22,29,	30)	(5,14,19,20, 30)	21,22,26,27,	(9,13,14,	15,17,18,26)
Dates of halos, lunar,	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

SUNSHINE RECORDS.

The importance of sunshine in plant development needs no comment. The method adopted by the United States Weather Service, of recording the per cent. of cloudiness at 8 A. M. and 8 P. M., affords only a moderate approximation to the real amount of sunshine; therefore, the desirability of determining more closely the amount of sunshine received by the vegetation of this locality. This was done by means of the apparatus described in an earlier report, by which the image of the sun, as it travels about a spherical reflector, traces a corresponding arc of a circle upon a sensitized paper placed in a camera focused upon the image in the reflector; any break in the sunshine causes a break of similar duration in the photographed path of the sun's image around the sphere. By this method it is possible to get a record only of the duration of sunshine, and not of the relative intensity.

The observations were begun before the sowing season in the spring and were continued to the last of September. The following table shows the daily duration of the sunshine during this period.

Sunshine Records for 1905.

	April.	May.	June.	July.	August.	September.
	H.-M.	H.-M.	H.-M.	H.-M.	H.-M.	H.-M.
1,	6-36	10-12	1-55	0	10-48	6-0
2,	10-48	6- 0	2-53	1-48	10-48	0
3,	9-30	8-24	11-24	8-24	11-24	4-48
4,	6-36	10-12	3-14	0-36	8-24	6-0
5,	7-12	0	2-24	0	9-36	6-0
6,	2-24	0	0-22	0-36	10-12	6-36
7,	4-48	9- 0	0	5-24	7-12	7-12
8,	4-48	10-48	10-26	9-36	4-48	5-24
9,	12- 0	10-12	9-36	9-36	6- 0	9-36
10,	4-48	1-12	4-48	7-12	1-12	4-12
11,	1-48	1-48	0-15	4-48	6-36	0
12,	9-36	8-24	4-12	1-48	2-38	4-48
13,	8-24	9- 0	12- 0	3- 0	0-36	2-24
14,	6- 0	0-29	12- 0	7-12	0-36	12-0
15,	4-12	1-12	9-36	11-24	4-48	0-36
16,	1-48	0	2-24	10-48	3- 0	0-58
17,	1-48	8-24	4-12	12- 0	7-48	0
18,	4-48	4-48	7-12	10-12	9- 0	7-12
19,	10-48	2-24	10-12	1-48	6-36	7-48
20,	1-12	10-48	8-24	7-48	4-12	4-48
21,	0	12- 0	0-36	7-12	6- 0	7-48
22,	10-12	7-48	0	0-22	8-24	10-12
23,	12- 0	10-48	0	1-12	10-12	12-0
24,	10-48	12- 0	1-48	9-36	4-48	12-0
25,	10-48	12- 0	11-24	10-12	0	12-0
26,	1-12	0	7-12	7-48	10-48	12-0
27,	6-36	4-48	10-12	10-48	12- 0	7-48
28,	9- 0	10-12	7-48	3- 0	10-12	9-36
29,	2-24	9- 0	10-48	0- 7	3- 0	10-48
30,	9-36	0-15	11-24	0-15	2-24	12-0
31,	.....	0	.....	0-36	10-48	.....
Means,	6-24	6-12	5-57	5-19	6-36	6-45

Mean Daily Sunshine. 1887-1905. (Hours and Minutes.)*

	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1899.	1900.	1901.	1902.	1903.	1904.	1905.
	H-M	H-M	H-M	H-M	H-M	H-M	H-M	H-M	H-M	H-M	H-M	H-M	H-M	H-M	H-M	H-M	H-M	H-M
April,	.....	6-54	.....	6- 7	6-43	5- 7	4-14	5-31	4-15	5-42	5-58	7-24	6-50	5- 8	5- 3	4-39	3-31	6-24
May,	.....	5-44	.....	5-26	5-28	5- 6	5-51	4-29	6-58	5-27	5- 3	6-19	7-45	6-23	7-57	6- 3	7-01	6-12
June,	10-10	9-22	.....	9- 1	8- 5	7-30	6-22	5-58	5-10	4-57	6- 7	6- 1	7-34	9-20	7-18	4-35	6-33	5-57
July,	7-20	9-44	4-17	11-33	8- 4	9-10	7-52	6-56	2-39	5-26	5-29	6-48	8-54	8-52	7-20	1-55	6-31	5-19
August,	6-45	8-18	4-50	7-41	6- 2	7-38	7-44	6-29	5-39	5-15	6-50	8-13	9-25	7-58	9-81	6-57	6-08	6-36
September,	4-42	4-10	2-28	5-23	7-22	6-12	3-32	4-18	5-30	5-25	7- 2	7-54	8- 2	8-12	7- 9	7-41	5-19	6-45
October,	3-10	3-19	3-53	2-57	4-39	4-35	4-33	4-30	5-40	3-38	4- 6	.....	.....	.....	.....	.....	.....	.....
November,	2-17	3-42	1-45	3-29	4-11	4-11	4- 3	3-32	4-20	.....	.....	.....	.....	.....	.....	.....	.....	.....

*Records for 1898 omitted.

WEEKLY CROP REPORTS.

For several years past the Station has been making weekly crop reports during the growing seasons to the Pennsylvania State Weather Service. Such reports are made from different portions of the State with a view to establishing a permanent record by which comparisons may be made in succeeding years.

These reports cover the period from April 7 to September 30, and contain the daily maximum and minimum temperatures, the approximate daily percentage of sunshine and the daily rain-fall. Besides these specific data, are reported under the head of "General Remarks" the effect of the weather on crops, with their condition and progress during the week; also the damaging effects of high winds, excessive rains, drought, frost, hail, etc.

The following table gives, besides the general remarks, the mean weekly maximum and minimum temperatures, the mean percentage of sunshine and the total weekly rain-fall. The reports cover the week ending with the date of the report.

Summary of Weekly Crop Reports for 1905.

Report for the Week Ending—	Mean of maximum temperature.	Mean of minimum temperature.	Per cent. of sunshine.	Rainfall in inches.	Remarks.
April 7,	56.3	35.0	56.4	.63	Wheat, rye, clover and timothy in good condition, not frozen out and have started growth; alfalfa frozen out on knolls; oats being sown.
April 14,	56.4	40.1	56.4	1.16	Wheat and rye looking very well; grass coming on nicely.
April 21,	46.0	30.5	29.0	.53	Crops looking well.
April 28,	65.0	41.0	83.0	.02	Corn and potatoes being planted; oats up; wheat looking well.
May 5,	68.0	49.0	56.0	.10	Corn planting still in progress; wheat and rye in fair condition; clover and timothy growing well; early potatoes coming through; ground too dry for good growing conditions.
May 12,	67.4	46.7	49.0	.92	Corn planting finished; rye heading out; crimson clover beginning to blossom; oats and grass growing well; conditions improved.
May 19,	66.0	54.0	31.0	1.15	Wheat and oats growing well; rye well headed; crimson clover in full blossom; corn coming up; soil conditions good.
May 26,	65.3	44.0	63.6	1.18	Crops doing well; corn starting nicely; red clover blossoming; frost on 21st and 24th, damaging gardens slightly.
June 2,	70.0	53.0	35.0	.67	Ground wet; wheat heading out; crops generally doing well.
June 9,	70.0	51.0	45.0	1.80	Crops looking well; corn coming on nicely; timothy heading.
June 16,	79.0	62.0	54.0	.41	All crops doing well.
June 23,	81.0	67.0	36.0	1.34	Wheat is turning yellow; timothy being cut for silage; corn and potatoes doing well.
June 30,	74.0	54.0	72.0	.49	Hay making in progress; oats heading out; wheat ripening nicely; corn doing well.
July 7,	77.0	66.0	20.0	.65	Corn still doing well; potatoes well in blossom; wheat good, ripe and harvesting begun; hay making still in progress; second crop clover starting nicely; oats well headed out but is lodging in places.
July 14,	82.0	64.0	51.0	1.53	Wheat harvest about over; oats beginning to ripen; clover, corn and potatoes doing well.
July 21,	82.0	65.0	73.0	Trace.	Corn in tassel; second crop clover doing well; some barley has been cut.
July 28,	73.0	56.0	51.0	.87	Wheat being threshed; corn and clover still doing well.
August 4,	73.0	56.0	44.0	.89	Oat harvest about over; corn and clover still doing well; blight beginning to appear on potatoes.
August 11,	84.0	64.0	54.0	.51	Oats, fine crop, threshing in progress; early potatoes maturing; second crop clover about ready to cut.
August 18,	75.0	61.0	34.0	2.05	Corn doing well; potatoes are maturing and tops dying; fall plowing well under way.
August 25,	76.0	58.0	45.0	1.52	Second crop clover being cut; corn being cut for ensilage; threshing and plowing still in progress.
September 1,	75.0	55.0	66.0	.07	Corn doing well; potatoes being raised; cutting of second crop clover still in progress; ground being prepared for wheat and some wheat has been sown.
September 8,	71.0	56.0	43.0	.61	Wheat being sown; early sown wheat coming up; last of the potatoes being raised.
September 15,	68.0	51.0	40.0	.74	Some late hay making in progress; wheat sowing still in progress; some wheat is up and looking fine.
September 22,	75.0	59.0	46.0	.53	Corn being cut up for fodder.
September 29,	71.0	46.0	91.0	0	Corn cutting about finished; second crop hay all cut; wheat doing well; ground getting dry; frost on 27th.

NOTES ON THE METEOROLOGY OF 1905.

To represent still more completely the seasons of 1905 in their relations to agriculture, a summary is presented below of those data most important from an agricultural standpoint, grouped so as to show the totals for the entire year, for the winter of 1904-1905, and for the growing season of 1905, and to this are added a few of the more important indicative facts concerning the season expressed in terms of the development of the several staple crops.

Annual Summary.

Mean barometer for the year (corrected and reduced),	30.045
Highest barometer for the year (Dec. 28),	31.222
Lowest barometer for the year (Jan. 22),	29.265
Mean annual temperature,	47.6 deg. Fahr.
Highest temperature (June 19),	89.0 deg. Fahr.
Lowest temperature (February 14),	—11.0 deg. Fahr.
Annual range of temperature,	100.0 deg. Fahr.
Mean daily range for the year,	17.1 deg. Fahr.
Greatest daily range (April 4),	45.0 deg. Fahr.
Least daily range (January 2, October 31, December 19, 20),	3.0 deg. Fahr.
Mean daily relative humidity,	83.3 per cent.
Annual rainfall,	37.08 inches.
Greatest monthly rainfall (August),	4.28 inches.
Greatest daily rainfall (March 21),	1.33 inches.
Days on which 0.1 inch or more rain fell,	133
Mean percentage of cloudiness,	48.4 per cent.
Days on which cloudiness averaged 80 per cent. or more,	105

Winter of 1904-05, October-March.

Mean temperature,	31.8 deg. Fahr.
Lowest temperature (February 14),	—11.0 deg. Fahr.
Total rainfall (rain and melted snow),	12.72 inches.
Total snowfall,	47.10 inches.
Greatest monthly snowfall (January),	16.20 inches.
Greatest daily snowfall (March 4),	6.90 inches.
Days on which snow fell,	50
Days on which cloudiness averaged 80 per cent. or more,	62

Growing Season of 1905, April-September.

Mean temperature,	61.7 deg. Fahr.
Highest temperature (June 19),	89.0 deg. Fahr.
Lowest temperature (April 17),	18.0 deg. Fahr.
Mean daily range,	18.5 deg. Fahr.
Greatest daily range (April 4),	45.0 deg. Fahr.
Last frost in spring,	May 24.
First frost in fall,	September 26.
Mean relative humidity,	78.4 per cent.
Total rainfall,	19.83 inches.
Greatest daily rainfall (August 12),	1.17 inches.
Days on which .01 inch or more rain fell,	72
Mean percentage of cloudiness,	43.7 per cent.
Days on which cloudiness averaged 80 per cent. or more,	38
Average hours of sunshine per day,	6 hrs. 12 min.

Principal Periods of Crop Development.

Wheat:	
Seeded,	Sept. 5, 1904.
In bloom,	June 2, 1905.
Ripening,	June 30.
Harvested,	July 7.
Oats:	
Seeded,	April 7.
Ripening,	July 14.
Harvested,	Aug. 4.
Corn:	
Planted,	April 28.
Cut,	Sept. 22.
Potatoes:	
Planted,	April 28.
Harvested,	Sept. 8.
Grass:	
Cut,	June 30.
Clover:	
In bloom,	May 26.
Cut,	June 30.

TEMPERATURE AND RAINFALL—EXCESSES AND DEFICIENCIES OF WEEKLY AVERAGES.

In order to meet inquiries frequently made concerning the weather of the current seasons as compared with corresponding brief periods in earlier years, a set of averages by weeks has been prepared from the data for mean daily temperature and rainfall for the years 1883 to 1905, both inclusive, but omitting the year 1885, the data for which were incomplete. The following summary shows the variations of 1905 from the averages for twenty-one years, excess and deficiency being respectively indicated by the plus (+) and minus (—) marks prefixed to the figures:

Weekly Average of Temperature and Rainfall.

Weeks.	Temperature (Deg. Fahr.)			Rainfall (Inches).		
	22 year mean.	1905.	Excess or deficiency.	22 year mean.	1905.	Excess or deficiency.
1. January 1-7,	25.0	27.0	+2.0	.74	2.23	+1.49
2. January 8-14,	24.9	21.4	—3.5	.73	.64	—.09
3. January 15-21,	26.2	28.3	+2.1	.57	.0	—.57
4. January 22-28,	25.6	17.1	—8.5	.66	.29	—.37
5. January 29-February 4,	25.1	9.3	—15.8	.57	.03	—.54
6. February 5-11,	25.1	15.0	—10.1	.72	.76	+.04
7. February 12-18,	26.3	15.0	—11.3	.84	.42	—.42
8. February 19-25,	28.1	31.0	+2.9	.61	.05	—.56
9. February 26-March 4,	29.1	25.3	—3.8	1.10	.69	—.41
10. March 5-11,	32.7	29.1	—3.6	.78	.74	—.04
11. March 12-18,	34.2	37.1	+2.9	.46	.01	—.45
12. March 19-25,	38.2	42.3	+4.1	.94	2.33	+1.39
13. March 26-April 1,	38.2	54.2	+16.0	.70	.17	—.53
14. April 2-8,	41.6	40.8	—.8	.66	.63	—.03
15. April 9-15,	45.4	46.7	+1.3	.88	1.16	+.28
16. April 16-22,	49.6	38.3	—11.3	.58	.54	—.04
17. April 23-29,	54.3	56.1	+1.8	.52	.13	—.39
18. April 30-May 6,	57.3	57.4	+.1	.78	.47	—.31
19. May 7-13,	59.0	58.1	—.9	.65	.45	—.20
20. May 14-20,	54.3	58.1	+3.8	.99	1.15	+.16
21. May 21-27,	60.5	56.7	—3.8	.77	1.18	+.41
22. May 28-June 3,	62.5	61.0	—1.5	1.04	.67	—.37
23. June 4-10,	65.9	61.7	—4.2	.82	1.84	+1.02
24. June 11-17,	68.3	71.4	+3.1	.95	.37	—.58
25. June 18-24,	68.4	73.0	+4.6	1.11	1.57	+.46
26. June 25-July 1,	68.0	64.3	—3.7	1.13	.29	—.84
27. July 2-8,	67.5	72.0	+4.5	.64	1.01	+.37
28. July 9-15,	68.8	72.4	+3.6	.86	1.11	+.25
29. July 16-22,	67.0	72.0	+5.0	.93	.38	—.55
30. July 23-29,	70.6	65.0	—5.6	.93	1.00	+.07
31. July 30-August 5,	69.6	65.4	—4.2	.70	.38	—.32
32. August 6-12,	69.1	73.0	+3.9	1.01	1.68	+.67
33. August 13-19,	68.2	65.8	—2.4	.82	.88	+.06
34. August 20-26,	67.8	65.9	—1.9	.97	1.52	+.55
35. August 27-September 2,	68.6	65.6	—3.0	.82	.13	—.69
36. September 3-9,	65.4	63.6	—1.8	.59	.35	—.24
37. September 10-16,	63.5	60.0	—3.5	.68	.72	+.04
38. September 17-23,	61.4	66.7	+5.3	1.00	.53	—.47
39. September 24-30,	58.0	59.0	+1.0	.69	0	—.69
40. October 1-7,	55.6	58.0	+2.4	.55	1.09	+.54
41. October 8-14,	53.3	54.7	+1.4	.81	.98	+.17
42. October 15-21,	50.3	55.0	+4.7	.55	1.06	+.51
43. October 22-28,	47.0	42.0	—5.0	.62	.04	—.58
44. October 29-November 4,	48.0	37.4	—10.6	.54	.48	—.06
45. November 5-11,	42.4	38.2	—4.2	.64	.35	—.29
46. November 12-18,	40.3	36.9	—3.4	.55	.19	—.36
47. November 19-25,	38.4	36.2	—2.2	.75	.06	—.69
48. November 26-December 2,	32.1	33.5	+1.4	.58	2.32	+1.74
49. December 3-9,	31.0	33.1	+2.1	.62	1.21	+.59
50. December 10-16,	30.9	30.3	—.6	.66	Trace	—.66
51. December 17-23,	29.9	34.7	+4.8	.67	1.12	+.45
52. December 24-31,	28.9	41.7	+12.8	.60	1.25	+.65

The average deficiency in weekly temperature for 1905 is .65 deg. Fahr.
The average deficiency in weekly rainfall for 1905 is .01 inches.

WEATHER SIGNALS.

By arrangement with the State Weather Service and through the courtesy of the Pennsylvania Railroad, the Station is in daily receipt of the weather predictions for Pennsylvania, issued by the United States Weather Bureau. These predictions cover the weather, (rainy or fair,) temperature and wind for the day of issue. To secure a speedy and wide-spread dissemination of these predictions, the States Weather Service has issued signal flags, by means of which the weather and temperature for thirty-six hours after 7 A. M. of the day for which the prediction has been made, may be indicated. These flags the Station displays from the flag-staff on the top of the College tower, whence they are visible for quite a distance on every side.

DIVISION OF AGRICULTURE.

GEO. C. WATSON, M. S., Agriculturist.
F. W. CHRISTENSEN, B. S., Asst. in Agr.
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REPORT OF THE AGRICULTURIST.

To the Director:

Sir: I have the honor to present herewith a report of the work of the Division of Agriculture for the present fiscal year. While a considerable part of the work of the department consists in carrying on year after year experiments that were established many years ago, yet a new line of work has been taken up which deserves more than a passing notice.

Of the work that is repeated year after year the fertilizer experiments and the tests of varieties of wheat, oats and potatoes form the larger part. The fertilizer tests have been conducted for 24 years, and were designed to test the efficiency of various fertilizer ingredients on corn, oats, wheat and grass, in an ordinary four years' rotation. The results published in former years are corroborated by the results obtained in recent years. In fact the more recent computations of the results seem to warrant the expression of more positive statements than the earlier results seemed to justify. The results of these tests are, each year, becoming more valuable.

These tests have been continued for a longer period than have any similar tests that have been made by American Experiment Stations and consequently the average results of all the years show that the effect of season is most nearly eliminated.

During the past year the variety tests of wheat, oats and potatoes have been continued. The results of these tests show a continued marked difference in the productiveness of the various varieties when grown under practically the same cultural conditions. These tests tend to show that the production of wheat, oats and potatoes in Pennsylvania may be very much increased by greater care in the selection of seed. During the past year tests of soiling crops were made which included Canada field peas and oats, alfalfa, cow peas and flat peas, as well as rye, clover and corn, which are grown for fodder each year on the Experiment Station farm.

During the past year $1,250 out of $2,500 appropriated for new buildings was assigned for the erection and equipment of poultry houses in order that the Station might begin some experimental work with poultry. As it had been impossible for some years previous to hatch chickens by means of incubators on account of the insurance on the buildings, the stock of fowls formerly maintained

by the College had become very much depleted. It was, therefore, necessary to expend a considerable proportion of the appropriation for the erection of an incubator building and for the purchase of fowls that could be used as foundation stock which could be used for experimental purposes. Consequently a one-story brick incubator building 19 feet by 25 feet was erected. This building affords ample space for incubators for experimental purposes, yet had the appropriation permitted the erection of a larger building, more satisfactory incubation would have been undoubtedly carried on, as it is difficult to secure satisfactory ventilation of small buildings without creating drafts. As the appropriation was to be used both for the construction of buildings and for equipment, it seemed advisable to erect several comparatively cheap brooder and colony houses which could be used most advantageously in the rearing of young fowls and could also be used as colony houses for mature fowls during a considerable proportion of the year. Six such houses have been constructed as well as some smaller houses that are used wholly for rearing young chickens. In addition to the permanent equipment mentioned two permanent poultry houses 12 feet by 20 feet with cement floors have been erected. The above mentioned new buildings in addition to the poultry houses which have been in use for a number of years will afford space for housing a sufficient number of fowls to warrant the undertaking of some extended experiments. At the present time the Station is maintaining flocks representing four classes of fowls, three of which are being used for experimental purposes. Barred Plymouth Rock, Wyandotte and Rhode Island Red of the American class; White Leghorn and Black Minorca of the Mediterranean class; Light Brahma and Buff Cochins of the Asiatic class. A small flock of White Crested Black Polish has been maintained by the College for several years for educational purposes; these for the present are not being used for experimentation.

In order that this division of the Experiment Station may be sufficiently well equipped to carry on the work which the poultrymen of Pennsylvania and the manufacturers of incubators and brooders have asked it to take up, I would recommend the appropriation of sufficient funds to build two permanent poultry houses and to better equip the division with incubators, brooders and other appliances that are most essential to the equipment of a modern poultry establishment. About $500 is needed for equipment and at least $500 for poultry buildings.

Most respectfully submitted,

G. C. WATSON,
Agriculturist.

FORAGE AND SOILING EXPERIMENTS, 1905.

BY GEORGE C. WATSON AND THOS. I. MAIRS.

SUMMARY.

1st. Of the crops grown during the season of 1905 a mixture of Kaffir corn and cow peas produced the largest yield of green substance per acre. This crop was satisfactory from the feeders' standpoint as the cows ate it well and it was entirely satisfactory from the standpoint of milk production.

2d. Alfalfa produced the largest yield of air-dry substance per acre. This crop is always satisfactory as a green forage whenever a good yield is secured.

3d. Oats and peas are satisfactory as a soiling crop for several reasons:

(a) They are among the earliest crops to ripen.

(b) Cattle consume this crop with relish.

(c) If more is grown than is needed for green forage it may be cured and will make a fine quality of hay.

(d) It may be harvested as a grain crop and when threshed and ground will make an excellent stock food.

(e) This crop may be harvested early enough to sow a second crop of cow peas.

4th. Three cuttings of alfalfa produced a total of over 1,300 pounds of protein per acre being more than that produced by any other crop and even more than that produced by any two crops that were grown in succession.

5th. Rye produced the earliest soiling crop and gave a large yield of dry substance per acre but under average conditions it ripens too quickly to prove most satisfactory from a feeder's standpoint.

6th. Of the various crops tested during the last four years, alfalfa produced the largest yield of dry matter per acre as well as the largest yield of protein per acre, the yield of protein per acre being far in excess of that produced by any other crop.

7th. The different forage crops tested seemed to have little if any effect upon the composition of the milk.

8th. The cows seemed to hold up better in milk production when on alfalfa than when on any other crops tested.

9th. Considering the fact that the cows were nearing the close of their milking period, they seemed to hold up well when on cowpeas and Kaffir corn and when on cowpeas alone.

During the season of 1905, tests were made of various soiling crops for the purpose of determining a practical succession of crops that would be most satisfactory for soiling purposes. These tests were

similar in nature to those made in 1902, 1903 and 1904. Leguminous crops were preferred and were selected so far as they could be used to good advantage in making up a satisfactory succession of crops. The tests made in 1905 may be considered a continuation of those made in previous years. A summary of all tests is given in Table III. The crops tested were as follows:

Rye.
Alfalfa.
Timothy and clover.
Oats and peas.
Soja beans.
Cow peas.
Kaffir corn and cow peas.

Table I gives the date of sowing, the date of harvesting and the yield per acre of both green substance and air-dry matter of the crops tested in 1905.

The air-dry matter was determined by drying samples of the fresh green forage somewhat dryer than ordinary field-cured hay. These samples were then left exposed to the air in a dry place in order that they might absorb moisture from the atmosphere and become what the term implies—thoroughly "air dried.

Table I.—Yields of Soiling Crops.

Crop.	Date of Sowing.	Date of Harvesting.	Yield per Acre.	
			Green substance. Pounds.	Air dry substance. Pounds.
Rye,		May 9-May 30,	21,974	4,569
Alfalfa,*		June 2-June 16,	13,997	4,459
Timothy and clover,		June 17-June 20,	17,461	4,482
Oats and peas,	May 10,	June 21-July 5,	20,951	2,973
Alfalfa,*		July 6-July 28,	9,531	2,324
Soja beans,	May 22,	July 29-August 7,	15,604	3,238
Cow peas,	June 10,	August 8-August 13,	21,663	3,089
Kaffir corn and cow peas,	June 28,	August 14-August 30,	33,443	5,542
Alfalfa,*		August 31-September 4,	6,277	1,607
Cow peas,	June 27,	September 5-September 19,	22,451	3,525
Total alfalfa,			29,805	8,390

From this table it will be observed that Kaffir corn and cow peas gave the largest yield of green substance per acre and the largest yield of air-dry substance at a single cutting, viz: (5,542 pounds) or a trifle over two and three-fourth tons per acre.

Alfalfa gave the largest yield of air-dry substance per acre (8,390 pounds) or a little over four tons. This crop not only produced a large amount of green forage and dry matter per acre but had a long period of harvesting. If the first crop is cut early, the second crop will have reached a considerable size by the time the first crop is finished so that the intervals between cuttings need not be very great, particularly if a field of considerable size is available.

From the feeder's standpoint, alfalfa, oats and peas, cow peas and Kaffir corn, and Soja beans were all satisfactory, cow peas, however, being preferred to Soja beans.

While not mentioned in the table, it may be said, however, that corn is always a most satisfactory green forage crop late in the season. Corn may be fed to advantage whenever the ears are well formed.

Table II gives the yield of dry substance per acre, percentage of nitrogen in the air-dry matter, the amount of nitrogen produced per acre and the amount of protein per acre.

Table II.—Yield of Nitrogen per Acre.

Crop.	Yield, dry substance per acre.	Per cent. of nitrogen.	Nitrogen per acre.	Protein per acre.
Rye,	4,569	1.64	74.93	468.31
Alfalfa, first cutting,	4,459	2.397	106.88	668
Timothy and clover,	4,482	1.99	89.19	557.43
Oats and peas,	2,973	2.68	79.67	497.93
Alfalfa, second cutting,	2,324	2.702	62.79	392.43
Soja beans,	3,238	2.11	68.32	427.00
Cow peas,	3,089	2.75	84.94	530.87
Kaffir corn and cow peas,	5,542	1.37	75.92	474.50
Alfalfa, third cutting,	1,607	3.11	49.97	312.31
Cow peas,	3,525	2.88	101.52	634.50
Total alfalfa,	.....	.....	219.64	1,372.00

From this table it will be seen that alfalfa contains a somewhat higher percentage of nitrogen than that of any other crop. The three cuttings of alfalfa also produced much more protein per acre than was produced by any other crop. The three cuttings of alfalfa produced much more protein during the season than was produced by oats and peas and cow peas, which were grown on the same land. Aside from alfalfa, the oats and peas followed by cow peas gave the largest yield of protein per acre.

Table III.—Yield of Dry Matter and Protein per Acre.

Soiling Crops.	1902.		1903.		1904.		1905.	
	Dry matter.	Protein.	Dry matter.	Protein.	Dry matter.	Protein.	Dry matter.	Protein.
Alfalfa,	.....	.....	6,555	1,145	6,555	1,145	8,390	1,372
Clover and timothy,	2,319	261	.....	.....	.....	.....	4,482	557
Corn,	.....	.....	5,456	406	.....	.....	.....	.....
Cow peas,	4,071	382	2,734	514	3,232	462	3,525	634
Flat peas,	3,565	720	5,677	.....	3,701	574	.....	.....
Peas and oats,	2,666	379	2,526	373	3,329	485	2,973	498
Rape,	3,136	388	5,006	439	.....	.....	.....	.....
Soja beans,	2,016	270	2,999	355	2,505	317	3,238	427
Sorghum and cow peas,	5,519	390	5,358	405	.....	.....	.....	.....
Kaffir corn and cow peas,	.....	.....	.....	.....	.....	.....	5,542	475
Rye,	.....	.....	3,406	272	.....	.....	4,569	468

Table III gives the yield of soiling crops both as to dry matter and protein for each of the four years during which these tests have been conducted. From the foregoing table it will be seen that alfalfa has produced a greater weight of dry matter per acre and also a greater weight of protein per acre than was produced by any other crop during either of the three years that a record has been kept of alfalfa. It will also be noticed that the yield of alfalfa with one exception was greater than that of any two crops that could have been grown in succession on the same land during one season. In 1905 peas and oats which were followed by Kaffir corn and cow peas gave a slightly greater yield of dry matter than was produced by alfalfa.

These trials of alfalfa tend to show that it is one of the most valuable crops for soiling and for hay wherever it can be grown satisfactorily. It is undoubtedly true that in Pennsylvania there is much land that will produce a satisfactory growth of peas and oats and perhaps cow peas but it contains too much moisture during the winter for the successful growth of alfalfa. From these trials greater attempts to cultivate alfalfa in Pennsylvania seem to be justified. There are undoubtedly many farms in Pennsylvania that would produce alfalfa satisfactorily where it is at the present time quite unknown.

On the whole peas and oats have been a most satisfactory soiling crop as well as a crop that could be recommended for hay. This crop may be sown early in the spring and will produce one of the earliest sown forage crops. Wherever Canada field peas will grow well, peas and oats are recommended both for soiling and for hay.

Cow peas and Kaffir corn produce a large yield of nitrogenous fodder. Soja beans have not been so satisfactory as cow peas. This is largely due to the fact that the stalks are more woody and are not so readily eaten.

For the experiment in 1905, four cows, Petty, Sister, May and Avina were selected. Avina was a registered Guernsey, the others were grades of the same breed. All were young cows with their second calves. Avina was fresh January 12; Sister, January 22; May, February 3, and Petty, February 24; so that they had been in milk from two and a half to four months at the time the experiment opened.

Table IV.—Amount of Forage Eaten per Cow Daily, Number of Days, and Live Weight at Close of each Period.

Crop.	Forage per day. Lbs	Number of days.	Weight of Cows. Petty. Lbs.	Sister. Lbs.	May. Lbs.	Avina. Lbs.
Rye,	39	22	665	650	728	826
Alfalfa, first cutting,	40	13	649	653	710	818
Timothy and clover,	40	4	644	634	701	816
Oats and peas,	40	15	639	637	703	808
Alfalfa, second cutting,	*49	23	656	644	708	829
Soja beans,	40	10	.....	.....	.....	.....
Cow peas,	40	6	647	649	694	819
Kaffir corn and cow peas,	40	17	654	656	681	835
Alfalfa, third cutting,	40	5	633	Dry	666	832
Cow peas,	40	15	637	Dry	652	815

*Sister fed 43 pounds per day.

Table IV gives the average amount of forage eaten per day by each cow, the number of days each crop was fed, and the live weight of the cows at the close of each feeding period. As some crops were fed a much longer time than others the influence of each upon the live weight is not readily apparent from this table. In general the cows seemed to just about hold their own. May is the only one that fell off any perceptible amount. Sister gained in weight but she was rather thin at the beginning of the experiment and went dry before the close. Petty and Avina lost slightly. The loss was hardly great enough to be significant. Of most of the crops, the cows were fed 40 pounds per day. Of the second cutting of alfalfa they were fed 50 pounds per day during the greater part of the time.

Table V.—Yield of Milk per Day.

Crop.	Number of days.	Yield of Milk per Day. Petty.	Sister.	May.	Avina.	Total.
Rye,	22	18.96	14.97	14.85	17.06	65.84
Alfalfa, first cutting,	13	17.72	12.95	11.50	15.57	57.74
Timothy and clover,	4	17.30	12.29	11.30	15.18	56.10
Oats and peas,	15	16.05	9.88	9.20	14.10	49.23
Alfalfa, second cutting,	23	15.84	8.31	8.32	12.77	45.24
Soja beans,	10	14.02	5.73	6.61	10.59	36.95
Cow peas,	6	13.00	4.32	4.68	8.53	30.53
Kaffir corn and cow peas,	17	11.06	3.03	6.03	6.94	27.06
Alfalfa, third cutting,	5	9.98	Dry	5.32	5.84	20.14
Cow peas,	15	8.54	Dry	5.14	3.82	17.50

Table V gives the average yield of milk per day for the different cows and the average total daily yield for the various crops. There seems to be a gradual falling off in milk production such as might be expected of cows under ordinary conditions as the period of lac-

tation advances. The cow, Sister, went completely dry before the experiment closed. With the yields, as with the live weight, the variation in the length of periods which the different crops were fed makes the comparison somewhat difficult.

If we assume that the average milk production for the first three days on any crop was the normal production at the beginning of the period and that the average production of the last three days was the normal production at the close of the period, then we find the daily decrease in milk production for the different crops to be as follows: Rye, .39 pounds; alfalfa first cutting, .08 pounds; oats and peas, .39 pounds; alfalfa second cutting, .07 pounds; soja beans, .78 pounds; Kaffir corn and cow peas, .41 pounds; and cow peas alone, .48 pounds. The period of time during which the cows were fed timothy and clover, first crop of cow peas, and third cutting of alfalfa, was cosidered too short to warrant comparison of this kind. A study of the individual records shows that three of the cows gained in milk production during the first cutting of alfalfa and two of them gained during the second cutting. It will be seen by reference to Table I that the cows were fed more of the second cutting of alfalfa than of any other crop. The decrease in milk production on soja beans was larger than on any other crop but it was confined for the most part to one of the cows. The rapid decrease towards the close of the experiment on Kaffir corn and cow peas, together, and on cow peas alone may be in part at least attributed to the fact that the cows were nearing the close of the period of lactation and were naturally drying up.

Table VI.—Butter Fat and Total Solids in Milk.

Crop.	Petty.		Sister.		May.		Avina.		Average.	
	Butter-fat.	Total solids.	Butter-fat.	Total solids.	Butter-fat.	Total solids.	Butter-fat.	Total solids.	Butter-fat.	Total solids.
Rye,	4.6	13.77	4.6	13.77	5.8	14.73	4.8	14.04	4.83	14.05
Alfalfa, first cutting,	4.5	13.03	4.6	13.27	5.4	13.23	4.6	13.52	4.74	13.19
Timothy and clover,	5.2	14.49	5.4	14.61	5.2	13.99	4.8	13.64	5.14	14.17
Oats and peas,	4.6	13.77	4.4	13.03	5.55	14.73	4.6	13.52	4.74	13.73
Alfalfa, second cutting,	5.15	14.06	4.85	14.07	5.5	13.98	4.65	13.58	4.97	13.78
Soja beans,	4.45	13.59	5.35	14.67	6.2	14.82	4.6	13.40	4.98	14.19
Cow peas,	5.2	14.37	5.8	15.09	6.5	15.30	5.4	14.36	5.55	14.61
Kaffir corn and cow peas,	5.2	14.49	5.8	15.09	6.0	14.45	5.4	14.40	5.49	14.53
Alfalfa, third cutting,	5.8	15.71	.....	.....	6.3	15.31	6.1	15.70	6.01	15.59
Cow peas,	5.5	14.85	.....	.....	6.3	15.81	5.9	14.33	5.82	15.02

Table VI gives the per cent. of butter fat and total solids in the milk of the different cows for the various crops fed as well as the average per cent. of fat and of total solids. While there is some variation in these figures it is not thought to be sufficiently significant to attribute it to the feed.

VARIETY TESTS.

BY GEO. C. WATSON AND N. G. MILLER.

Since 1887, The Pennsylvania State College Agricultural Experiment Station has made tests each year of a limited number of varieties of wheat, oats, and potatoes, the object of these tests being to determine, as far as possible, for the limited number of varieties tested, the comparative productiveness of these varieties as raised in Pennsylvania. It was thought that perhaps a considerable difference in yield might be shown when all were grown under similar conditions, so far as such conditions could be secured on the Experiment Station Farm. From year to year some of the poorest yielding varieties have been discarded and promising new ones put in their places; consequently at the present time a collection of the most productive varieties is being tested. This bulletin, therefore, gives the yield of varieties which have been most productive, and does not show the difference in productiveness of varieties as they are grown by farmers throughout the State. The difference in productiveness, as shown by the farmers' yield, in Pennsylvania would undoubtedly be very much greater. In order that these tests of varieties may show the actual differences in productiveness, the conditions of soil, culture, fertilizer applied, amount of seed per acre, etc., have been as nearly uniform as possible. That differences in yield might not be caused by variations in the soil, due to location, duplicate plats have been planted in nearly all cases, the average yield of the two plats being taken as the yield of each variety.

THE SOIL.

The soil upon which these trials have been made is a fertile clay loam, underlaid with limestone rock having many fissures, so that good natural drainage is provided. There are many small pieces of flint scattered through this soil. In general, it may be said that this limestone clay soil represents fairly well the limestone soils of Pennsylvania south of the terminal morain or of the drift area.

The soil is perhaps somewhat too heavy for potatoes, but is well supplied with humus and is most productive corn and wheat land. This land has been well cultivated for many years and liberally fertilized with barn and commercial manures.

WHEAT.

The land used for the variety tests in 1903-4 was plowed eight inches deep, August 19, 1903. On August 27, the land was given a top dressing of barnyard manure at the rate of eight tons per acre. The land was thoroughly cultivated and the varieties sown, September 5, at the rate of seven pecks per acre. One hundred and

sixty pounds of dissolved South Carolina rock, containing 14 per cent. available phosphoric acid, was applied at the same time. The wheat came up well and made a good growth but was somewhat infected with Hessian fly. All the varieties looked quite well at the beginning of the winter. In the early part of March some of the land was covered with a thick sheet of ice which resulted in smothering nearly all the wheat so covered. The remaining wheat showed considerable damage from the Hessian fly at harvesting time. The varieties were cut July 19. The yield of the different varieties was so badly affected by the covering of ice and damage by fly, as to make it unreliable for comparison as to their relative merits, and is therefore not reported.

The land used for the tests in 1904-5 was plowed August 19. It was rolled twice and harrowed four times in preparation for seeding. The varieties were sown September 6. The ground was in good condition as regards fineness, quite dry and dusty on the surface, but moist underneath. Each variety was sown in duplicate, the main plat containing one twenty-eighth of an acre, or two drill breadths, and the duplicate plat one fifty-sixth of an acre, or one drill breadth. The seed was sown at the rate of eight pecks per acre. One hundred and sixty pounds of dissolved South Carolina rock, containing 14 per cent. available phosphoric acid, was applied at the same time.

The season was quite dry after the wheat was sown. There was a poor growth and very little tillering before November 1. During the latter part of October and early part of November there were several rains which caused the wheat to grow quite rapidly until cold weather set in. The ground was covered with snow most of the winter, making it very favorable for the wheat. The crop looked better relatively in the spring than it did in the fall. The weather during the spring months was also quite favorable and a good growth was made by all the varieties. The Fulcaster and Fultzo-Mediterranean varieties lodged badly. Nearly all the varieties were somewhat infected with rust, but not enough to materially affect the yield. The varieties were cut July 12 and threshed July 19. The following table gives the yields of the different varieties, the names being arranged in order of yield. The yields reported were obtained from careful weighings of straw and grain at the time of threshing.

Wheat—Yield of Varieties Tested in 1905.

Varieties.	Grain per acre. Bushel 60 pounds.	Straw per acre. Lbs.	Weight per struck bushel.	Bearded or smooth chaff.	Color of grain, red, white or amber.
1. Harvest King,	34.60	2,746	59.75	Smooth	Red
2. Martin Amber,	34.58	2,240	59.75	Smooth	Amber
3. Royal Red Clawson,	34.22	2,845	60.25	Smooth	Red
4. Fultzo Mediterranean,	33.96	3,230	60.75	Smooth	Red
5. Fulcaster,	33.64	2,171	60.75	Bearded	Red
6. American Bronze,	33.32	3,078	59.25	Smooth	Red
7. Mortgage Lifter,	32.46	2,367	59.75	Bearded	Red
8. Rural New Yorker, No. 57,	31.89	2,300	59.25	Bearded	Red
9. Turkish Amber,	31.04	2,956	60.75	Bearded	Amber
10. Rural New Yorker No. 6,	29.84	2,497	58.25	Smooth	Amber
11. Jones Longberry Red No. 1,	28.72	1,831	.....	Bearded	Red
12. Rochester Red,	28.28	2,618	58.25	Smooth	Amber
13. Forty Fold or Gold Coin,	27.28	2,335	59.75	Smooth	White
14. Beechwood Hybrid,	26.89	2,319	60.25	Smooth	Red
15. Dietz Longberry Red,	26.86	2,449	61.25	Bearded	Red
16. Fultz,	25.20	2,118	59.75	Smooth	Red
17. Dawson Golden Chaff,	25.20	1,851	58.25	Smooth	Amber
18. Ontario Wonder,	23.65	1,818	60.75	Smooth	Amber
19. Reliable,	23.56	3,130	61.25	Bearded	Red
20. Harvest Queen,	18.12	1,630	58.75	Smooth	Amber
Average of all varieties,	29.17	2,429	59.78		
Average of 13 smooth varieties,	28.86	2,413	59.44		
Average of 7 bearded varieties,	29.74	2,458	60.50		

From the foregoing table, it will be seen that Harvest King, a smooth chaff, red, wheat, gave the largest yield of grain of any varieties tested. While there was but little difference in the yield of many of the varities, the difference between the largest and the smallest yield is 16.45 bushels, which represents an increase of over 90 per cent. of the lowest yield, that made Harvest Queen. While the lowest yield of grain and the lowest yield of straw were both made by the same variety, yet there does not seem to be a very close relationship between the yield of grain and the yield of straw. To illustrate:—The Reliable, which gave next to the largest yield of straw, 3,130 pounds, gave next to the smallest yield of grain, 23.56 bushels. There does not seem to be a close relationship between the weight per struck bushel, the yield of straw, and the yield of grain.

A comparison of the smooth with the bearded chaff varieties shows that the latter produced 0.88 of a bushel of grain and 45 pounds of straw more, per acre, than the former. It is also noted that the latter produced grain weighing 1.06 pounds more per bushel.

In the following table the Reliable variety is used as a basis for comparison, as it has been the leading variety grown on the Station farm for many years. Of the varieties tested 15 years Fulcaster stands in the lead, producing 31.13 bushels of grain and 3,824 pounds straw per acre. The grain of this variety is large and is well liked by millers. The straw is inclined to be too weak, and to lodge badly when grown on fertile land.

Forty Fold, or Gold Coin, gave a little larger yield of grain than the Reliable.

Rochester Red is one of the best smooth chaff varieties, but is exceeded in both the yield of grain and straw by the Royal Red Clawson, another smooth chaff variety of considerable promise.

Of the varieties tested 6 years, Harvest King exceeded the Reliable by 0.85 bushels in yield of grain, and 145 pounds in yield of straw. Favorable reports have been received of this variety in southeastern Pennsylvania.

Of the newer varieties tested two years, Mortgage Lifter and American Bronze both promise very well, but are light in yield of straw as compared with the Reliable.

An average of former years shows a larger production of grain by the bearded varieties. There were a few years, however, when the smooth varieties produced the most grain and also when they produced the most straw.

Wheat—Average Yield of Varieties for all the Years Tested Except 1904.

Varieties.	Grain per acre. Bushel 60 pounds.	Straw per acre. Lbs.	Weight per struck bushel.
15 Years, 1890—1905:			
Fulcaster,	31.13	3,821	62.61
Reliable,	30.32	3,650	62.41
Dietz Longberry Red,	29.26	3,565	62.38
Ontario Wonder,	28.98	3,090	61.79
Fultz,	27.80	3,181	61.87
9 Years, 1896—1905:			
1. Reliable,	28.69	2,976	62.32
2. Forty Fold or Gold Coin,	28.93	2,804	60.14
3. Rochester Red,	27.75	2,978	60.47
8 Years, 1897—1905:			
1. Reliable,	28.66	3,240	62.05
2. Dawson's Golden Chaff,	28.86	3,153	59.75
7 Years, 1898—1905:			
1. Reliable,	27.60	3,009	61.94
2. Royal Red Clawson,	29.37	3,187	61.50
6 Years, 1899—1905:			
1. Reliable,	26.93	2,753	61.98
2. Harvest King,	27.78	2,898	61.91
3. Harvest Queen,	23.95	2,584	59.54
4. Fultzo Mediterranean,	23.66	2,532	60.74
5 Years, 1900—1905:			
1. Beechwood Hybrid,	24.88	2,728	61.94
2. Reliable,	27.29	2,697	61.86
4 Years, 1901—1905:			
1. Reliable,	28.54	2,745	61.31
2. Rural New Yorker, No. 57,	29.02	2,632	61.98
3. Jones Longberry Red, No. 1,	27.07	2,508	.....
4. Rural New Yorker, No. 6,	26.30	2,429	59.67
5. Martin Amber,	25.40	2,599	62.02
3 Years, 1902—1905:			
1. Reliable,	29.63	2,531	61.66
2. Turkish Amber,	28.68	2,212	62.51
2 Years, 1903—1905:			
1. Reliable,	28.09	2,964	60.97
2. Mortgage Lifter,	33.10	2,730	61.45
3. American Bronze,	30.11	2,481	60.62

OATS.

The oat varieties for 1904 were grown on a part of the plats of the series used for variety tests as described for wheat. The land, which was in potatoes the previous year, was plowed seven to eight inches deep and thoroughly cultivated. The varieties were sown May 4 with a force-feed grain drill at the rate of 8 pecks per acre. One hundred and sixty pounds of dissolved South Carolina rock, containing 14 per cent. available phosphoric acid, was applied at the time of sowing the oats. Each variety except Sensation was sown in duplicate, each plat and duplicate containing one twenty-eighth of an acre. The early part of the season was very favorable and moist, causing a rank growth of straw. Some of the varieties lodged badly. The varieties lodging the least were Silver Mine, Fourth of July, Lincoln, Great American and Long's White Tartar. Considerable rust appeared July 15 and developed rapidly on most of the varieties. Some of the heads did not fill well which may have been due, in part at least, to the rust. Long's White Tartar, Mortgage Lifter and Czar of Russia ripened the earliest and Giant Golden Side the latest. The varieties were cut August 5th, 6th, 8th and 9th and threshed August 11. For yield see subjoined table.

The oat varieties for 1905 were sown April 24, at the rate of 8 pecks per acre, and 160 pounds of dissolved South Carolina rock, containing 14 per cent. available phosphoric acid, was applied at this time. The oats came up on May 6 and made a good growth during the early part of the season. All the varieties produced a rank growth of straw and lodged badly. They were all cut July 27 and threshed August 4.

Oats—Yield of Varieties, 1904 and 1905.

Number.	Variety.	1904.		1905.		
		Grain per acre. Bushel 32 pounds.	Straw per acre. Lbs.	Grain per acre. Bushel 32 pounds.	Straw per acre. Lbs.	Weight per struck bushel.
1	Czar of Russia,	69.13	3,808	61.50	3,143	34.00
2	Big Four,	70.44	4,676	58.30	3,849	33.69
3	Sensation,	70.00	4,200	57.88	3,123	32.94
4	White Maine,	75.47	5,283	57.77	3,332	32.19
5	Long's White Tartar,	68.25	4,256	57.56	2,581	34.25
6	White Russian,	77.00	3,976	56.93	2,230	30.57
7	Irish Victor,	64.31	4,802	56.72	3,832	33.07
8	Heavy Weight Champion,	63.88	4,466	56.72	3,550	33.01
9	Fourth of July,	69.13	4,228	56.72	3,429	30.82
10	Golden Fleece,	64.53	4,515	56.62	3,432	34.00
11	Japan,	59.94	4,445	56.51	3,704	31.88
12	Great American,	63.00	4,634	55.88	3,254	33.26
13	Silver Mine,	70.00	4,830	55.78	3,728	33.32
14	Golden Giant Side,	71.75	5,402	55.57	3,492	30.01
15	Liberty,	67.81	5,256	59.94	3,755	33.94
16	New Danish White,	65.75	4,473	54.94	3,620	32.07
17	Probostier,	66.28	4,739	54.20	2,975	31.94
18	Lincoln,	59.94	4,312	53.36	3,361	30.31
19	Mortgage Lifter,	58.63	4,844	47.80	4,908	31.88
	Average,	67.12	4,586	56.09	3,436	32.48

It will be noticed that the yield of both grain and straw was larger in 1904 than in 1905. The relative yields do not stand in the same order for the two years although they are somewhat similar. White Russian gave the largest yield of grain, 77 bushels, and next to the smallest yield of straw, 3,976 pounds, in 1904; in 1905 it stood sixth in yield of grain and lowest in yield of straw. Mortgage Lifter was lowest in the yield of grain for both years but produced the largest yield of straw in 1905. The average yield of all the varieties for 1904 was 11.03 bushels of grain and 1,150 pounds of straw larger than in 1905.

The average of yield for all the years tested is given in the following table.

Oats—Average Yield of Varieties for all the Years Tested Except 1896.

Variety.	Grain per acre. Bushel 32 pounds.	Straw per acre. Lbs.	*Weight per struck bushel.
10 Years, 1895—1905:			
Japan,	52.83	3,251	33.86
Lincoln,	49.61	3,061	32.29
8 Years, 1898—1905:			
Japan,	53.25	3,344	35.67
Liberty,	55.70	3,347	33.75
Sensation,	52.22	2,798	33.91
Mortgage Lifter,	49.48	3,133	36.23
7 Years, 1899—1905:			
Japan,	53.65	3,371	33.83
White Maine,	61.90	3,349	32.57
Fourth of July,	56.80	2,950	31.36
Heavy Weight Champion,	55.47	3,126	32.45
Great American,	52.14	3,055	32.92
6 Years, 1900—1905:			
Japan,	52.92	3,293	33.99
Irish Victor,	56.93	3,063	32.78
Silver Mine,	57.35	2,935	32.86
5 Years, 1901—1905:			
Japan,	56.58	3,223	33.55
Golden Giant Side,	59.79	3,668	31.45
Czar of Russia,	60.28	2,932	33.84
New Danish White,	57.94	3,102	33.16
Probostier,	57.39	2,106	32.90
Big Four,	58.86	3,294	34.05
Golden Fleece,	54.47	3,011	33.54
3 Years, 1903—1905:			
Japan,	60.04	3,865	31.61
Long's White Tartar,	62.36	3,173	33.55
White Russian,	60.62	3,011	31.18

The Japan variety is used as a standard for comparison for the different years, as it has been the leading variety for several years on the Experiment Station Farm. It will be noted that it stands well in weight per bushel as well as in productiveness. It is exceeded in weight by only three varieties, namely, Czar of Russia, Big Four and Long's White Tartar. The varieties that promise a better yield of grain than the Japan are Liberty, White Maine, and Czar of Russia. In yield of straw the Golden Giant Side is the only

*Average weight per struck bushel does not include data for 1904.

variety that exceeds the Japan to any considerable extent, there being a difference of 385 pounds per acre.

POTATOES.

Tests in 1904.

All the seed used was treated for scab with a solution of corrosive sublimate (two ounces corrosive sublimate to sixteen gallons of water). The tubers were left in the solution for one and a half hours. The land used for the test was the same as described for the wheat variety tests and was in clover during the previous year. During the winter twelve tons of farm manure was applied per acre. The land was plowed on April 16 and put in good tilth by May 7 when the varieties were planted. No tubers were used for seed that did not weigh one and three-fourth ounces or over. The tubers were cut toward the stem end, mostly to one eye; as the tubers in nearly all the varieties averaged large, the pieces were correspondingly large. The pieces were dropped in rows three feet apart, covered four inches deep and placed fifteen inches apart in the row. After planting, the land was cultivated often enough to keep the weeds exterminated and the surface mellow. Level culture was given throughout the season. All the varieties made a very rank growth of stalk as the season was favorable for rapid growth.

The late blight appeared on some of the varieties July 31. All the varieties were sprayed on the 21st with Bordeaux mixture and Paris green. By the last of July nearly all the varieties had been attacked slightly by blight, but not enough to seriously affect the yield. The varieties were harvested September 16 and 17.

Tests in 1905.

The fertilization, cultivation and manner of planting was the same as described for 1904. The varieties were all treated with the corrosive sublimate solution and planted May 8 and 9. The varieties came up well, an even stand being secured. Some Colorado beetles were noticed June 22. All varieties were sprayed on June 26 with Bordeaux mixture and Paris green. The cultivation was sufficient through the season to eradicate the weeds and to keep a good earth mulch.

There was a heavy growth of stalk in all the varieties as the season was moist and warm. Late blight began to appear on some of the varieties July 11. All the varieties were sprayed with Bordeaux mixture and Paris green July 12.

The earliest maturing varieties are Eureka, Early Norwood, Pride of Michigan, Freeman, Extra Early Kidney, White Mountain, Early Andes, Irish Daisy, Six Weeks, Thorburn, Pingree, Polaris and New Bovee Seedling. The late maturing varieties are Delaware, Admiral Dewey, Crine's Lightning, Heath's Late Beauty, Maggie Murphy, Washington, White Mammoth, Carmen No. 3, Heath's Favorite, White Giant and Early Puritan. The remaining varieties are medium late in maturing. The varieties were dug September 6 and 7. The yield for 1904 and 1905 is given in the following table.

Potatoes—Yield of Varieties for 1904 and 1905.

Number.	Variety.	1904.	1905.			
		Total yield per acre. Bushels of 56 pounds.	Total yield per acre. Bushels of 56 pounds.	Merchantable tubers per acre. Bushels.	Unmerchantable tubers per acre. Bushels.	Per cent. merchantable tubers.
1	Eureka,	260.6	260.6	231.1	29.5	88.71
2	Heath's Medium Late Beauty,	324.8	233.8	229.1	4.7	97.98
3	Uncle Sam,	339.8	246.2	226.7	19.5	92.08
4	Early Rose,	307.8	237.8	211.1	27.6	88.44
5	Early Puritan,	285.3	224.2	208.5	15.7	93.00
6	Extra Early Crusader,	306.0	243.6	208.4	30.2	85.53
7	Irish Daisy,	234.1	225.4	207.8	17.6	92.18
8	Early Nancy,	328.8	231.8	205.4	26.4	88.60
9	Bliss Triumph,	290.8	231.0	203.8	27.2	88.24
10	Heath's Early Market,	308.9	225.4	199.7	25.7	88.58
11	Six Weeks,	211.3	231.5	198.6	32.9	85.79
12	Beauty of Hebron,	256.2	225.6	194.0	31.7	85.97
13	Pingree,	287.1	230.0	191.7	38.3	85.57
14	White Giant,	320.0	212.5	190.9	21.7	89.82
15	Delaware,	288.3	206.5	190.1	16.4	92.07
16	Carman No. 3,	390.2	211.5	188.1	23.3	87.70
17	Hiawatha,	239.6	206.2	188.1	18.1	91.23
18	Heath's Late Beauty,	311.1	203.4	186.7	16.7	91.78
19	Early Norther,	324.1	227.6	183.4	44.3	80.56
20	Heath's Favorite,	309.3	198.6	180.3	18.3	90.77
21	Thorburn,	308.2	216.8	172.5	44.3	79.58
22	Polaris,	281.5	193.6	163.8	29.8	84.62
23	Pride of Michigan,	315.8	197.6	161.4	36.2	81.70
24	Maule's Early Thorobred,	291.6	191.2	159.5	31.7	83.44
25	Admiral Dewey,	423.2	182.4	154.8	27.6	84.86
26	Badger Belle,	338.3	173.6	152.2	21.4	87.65
27	Early Norwood,	312.2	175.6	145.9	29.8	83.06
28	Early Andes,	220.4	169.2	145.9	23.2	86.20
29	Enormous,	179.8	166.6	137.8	28.8	82.69
30	Crine's Lightening,	291.2	150.3	137.4	12.9	91.42
31	Early York,	241.8	170.5	135.5	35.0	79.47
32	White Mountain,	157.6	157.2	131.0	26.2	83.31
33	Freeman,	250.5	168.5	127.5	41.0	75.68
34	Maggie Murphy,	171.1	152.2	127.2	25.0	83.60
35	Extra Early Kidney,	218.3	238.8	122.2	116.7	51.17
36	White Mammoth,	281.3	117.9	109.8	8.1	93.11
37	Irish Cobbler,	176.8	125.5	107.4	18.1	85.57
38	Carman No. 1,	215.3	109.7	96.3	13.3	87.80
39	New Bovee Seedling,	138.3	111.3	75.6	35.7	67.93
40	Rose of Erin,	196.6	85.6	73.5	12.1	86.01
41	Washington,	175.0	87.2	72.4	14.8	83.06
42	Early Vaughan,	145.9	93.6	66.0	27.6	70.49
43	J. A. Totten,	154.7	83.5	54.7	28.8	65.48
	Average,	264.9	187.0	159.4	27.4	84.71

The foregoing table is arranged in the order of the yield of merchantable tubers for 1905. It will be noticed that the order of yield for 1904 varies considerably from that of 1905. Admiral Dewey, which yielded 423.2 bushels in 1905 stands twenty-fifth in the list for 1905. The average total yield for all the varieties for 1904 is 77.9 bushels more than the yield for 1905. The season appears to have a marked influence on the relative yield of the different varieties. The growth of stalk for 1905 was sufficient in each instance to indicate a large yield of tubers but the season was too wet for their best development.

The average yield for all the years tested gives a truer comparison of the value of the different varieties. This record is shown in the table on a following page.

It will be noted that the Freeman variety is used as a basis for comparison and that most of the newer varieties excel it in productiveness. The Freeman variety has been grown on the Experiment Station farm for twelve years without a change of seed. If it is true, tion farm for twelve years without a change of seed. If it is true, as claimed by some potato raisers, that a change of seed tends to increase the yield, this may account in part at least, for the small yield of the Freeman. Of the varieties tested for ten years the Freeman stands second in the list; Carman No. 1 yielding 15.6 bushels more merchantable tubers but 3.5 bushels less total tubers. The Enormous variety did very well when first planted on the Station grounds, yielding at the rate of 480.8 bushels per acre in 1896. It stands 29th in yield for 1905, and 36th for 1904. This indicates an apparent running out.

White Giant is a large variety and stands high in the list of a seven years' test. Late Beauty and Late Surprise are also promising late varieties. The most promising early varieties are Early Rose, Extra Early Crusader and Eureka.

Potatoes—Yield of Varieties for all the Years Tested Except 1904.

Variety.	Merchantable tubers per acre. Bushel 56 pounds.	Unmerchantable tubers per acre. Bushel 56 pounds.	Total yield per acre. Bushel 56 pounds.	Per cent. merchantable tubers.
10 Years, 1895—1905:				
Freeman,	153.6	26.0	179.6	85.53
Carman No. 1,	169.2	13.9	183.1	92.41
New Bovee Seedling,	129.1	30.8	159.9	80.74
Irish Daisy,	149.8	19.1	168.9	88.69
Rose of Erin,	133.2	11.8	145.0	91.86
9 Years, 1896—1905:				
Freeman,	139.0	24.0	163.0	85.28
Enormous,	163.4	12.1	175.5	93.11
Maggie Murphy,	126.8	11.9	138.7	91.42
8 Years, 1897—1905:				
Freeman,	116.2	24.3	140.5	82.70
Polaris,	142.2	20.8	163.0	87.24
Washington,	139.4	11.1	150.5	92.62
Early Vaughan,	116.8	22.6	139.4	83.79
Maule's Early Thorobred,	120.5	25.4	145.9	82.59
7 Years, 1898—1905:				
Freeman,	112.7	23.8	136.5	82.56
Pride of Michigan,	174.3	22.2	196.5	88.70
White Giant,	186.7	11.2	197.9	94.34
Hiawatha,	163.5	11.4	174.9	94.05
Badger Bell,	150.0	17.6	167.6	89.50
Early Andes,	140.6	20.8	161.4	87.11
Early York,	137.5	17.6	155.1	88.65
6 Years, 1899—1905:				
Freeman,	118.4	22.7	141.1	83.91
Extra Early Crusader,	186.5	27.6	214.1	87.15
Irish Cobbler,	158.1	16.9	175.0	90.34
Six Weeks,	163.7	18.1	181.8	90.04
Beauty of Hebron,	142.0	22.2	164.2	86.48
J. A. Totten,	116.9	15.2	132.1	88.49
White Mountain,	102.3	8.7	111.0	92.16
5 Years, 1900—1905:				
Freeman,	118.5	22.3	140.8	84.16
Late Beauty,	198.7	9.5	208.2	95.44
Late Surprise,	206.8	6.5	213.3	96.95
Favorite,	176.0	10.4	186.4	94.42
White Mammoth,	159.4	9.9	169.3	94.15
Extra Early Kidney,	80.6	57.8	138.4	58.24
4 Years, 1901—1905:				
Freeman,	132.1	21.9	154.0	85.78
Early Norther,	205.6	34.3	239.9	85.70
Early Norwood,	185.6	26.7	212.3	87.42
Early Market,	197.8	25.7	223.5	88.50
Early Nancy,	199.5	29.3	228.8	87.19
Eureka,	200.3	28.3	228.6	87.62
Pingree,	186.5	26.6	213.1	87.52
Admiral Dewey,	178.4	16.3	194.7	91.63
Thorburn,	164.0	31.3	195.3	83.97
2 Years, 1903—1905:				
Freeman,	115.0	24.2	139.2	82.62
Early Rose,	216.2	28.3	244.5	88.43
Delaware,	175.8	20.9	196.7	89.37
Early Puritan,	175.9	26.0	201.9	87.12
Uncle Sam,	181.4	16.1	197.5	91.85
Crine's Lightening,	112.7	18.3	131.0	86.03
Bliss' Triumph,	141.4	25.4	166.8	84.77
Carman No. 3,	97.4	43.4	240.8	81.97

DIVISION OF ANIMAL INDUSTRY.

THOMAS I. MAIRS, M. S.

To the Director:

Sir: I have the honor to present herewith a report upon the work of the Division of Animal Industry for the year ending June 30, 1906.

In the main this has been a continuation of work already begun in the Division of Agriculture before the establishment of the Division of Animal Industry. The investigations have in general been along the lines of feeding for the production of beef and milk, and include the following experiments which have been in progress:

First. Feeding Soiling Crops for Milk Production.

Second. Preliminary Observations on the Protein Supply of the Dairy Herd.

Third. Comparison of Alfalfa Meal and Wheat Bran for the Production of Milk.

Fourth. Comparison of Barn vs. Shed for Fattening Steers.

Fifth. Comparison of Corn and Cob Meal vs. Broken Corn for Fattening Steers.

FEEDING DAIRY COWS.

The feeding of soiling crops was a continuation of the work of the past three years along the same line. Certain crops which had been fed in former years were omitted as not being worthy of further trial. The crops fed during the past year were rye, oats, peas, alfalfa, cow peas, corn, red clover and sorghum. A report of the results of this experiment will be found in a separate article.

The preliminary observations on the protein supply of the dairy herd which were partially reported in the last annual report were continued to January 1, 1906. While the results of these observations do not warrant any radical conclusions, it is thought that they are sufficient to indicate that beyond certain limits the supply of protein is of much less importance than was formerly considered, and that an excess of protein beyond that required for maintenance and for the protein of the milk does not stimulate a greatly increased production. A somewhat complete account of this work is given in a separate article.

The broad claims for alfalfa meal as a substitute for wheat bran and the extensive advertising which it has been given seemed to warrant a test of the relative merits of these two feeds. Ten cows on full flow of milk were used for this test which covered a period of twelve weeks. As shown in the article giving the details of this experiment no advantage was found in alfalfa meal over wheat bran. On the other hand alfalfa meal was higher in price and seemed somewhat less palatable.

FATTENING STEERS.

The shelter experiment with fattening steers which was begun in the fall of 1902 was continued again the past winter. The results seemed to corroborate completely those of former years, namely, that temperature does not affect the gains but that dry quarters are of very great importance.

Broken ear corn was compared with corn and cob meal for fattening steers. As a result of this trial neither form appeared to have an advantage over the other. The question, therefore, resolves itself into that of the relative cost of preparation. These two steer feeding experiments are the subjects of separate articles.

TUBERCULIN TEST OF STATION AND COLLEGE HERDS.

Under the direction of Dr. Leonard Pearson of the Live Stock Sanitary Board of Pennsylvania, a tuberculin test of the Station and College herds was made during the month of March. As the result of this test, fifteen animals were condemned, and were destroyed by Dr. E. P. Althouse, of Johnstown, Pa., on April 27 and 28. All of the animals destroyed were found to be affected, but most of them to only a slight extent. This would indicate that the disease was either of recent origin or that the conditions under which the animals had been kept had prevented its extensive development. Of the animals destroyed nine were cows, five were heifers and one was the registered Guernsey bull, Lucretia's Glenwood Boy of Haddon, 9,264. This bull was undoubtedly one of the best bred Guernseys in America. One of the cows was also a registered Guernsey, Flovina, 12,492.

As the herd was free from tuberculosis when last tested and as no animals had been bought except the bull which was purchased subject to the tuberculin test and which came from a farm said never to have had a case of tuberculosis, the appearance of the disease here was quite unexpected. During the summer of 1902 some of the heifers and one cow were taken to a pasture in the mountains. Here they ran for some months with about two hundred head of other cattle. It is probable that the disease was contracted by some of these from the strange cattle in this pasture and then transmitted to others in the Station herd.

The barns have been thoroughly disinfected under the direction of the Live Stock Sanitary Board and it is hoped that no further development of the disease will take place.

MILKING MACHINE.

During the month of April, the manufacturing plant of D. H. Burrell and Co., at Little Falls, N. Y., was visited for the purpose of investigating the Burrell-Kennedy-Lawrence cow milker. The machines were examined in the factory and operated on cows in two different herds. As a result an order has been placed for two of these machines to compare them with hand milking. The general interest in mechanical milking seemed to warrant an investigation of its merits.

During the past year the hog sheds which had formerly been used for experimental purposes were destroyed, as their condition

had become such that they were thought to be a menace not only to any hogs kept in them but to the dairy herd as well. At the present time, therefore, the Station is without any facilities for keeping hogs.

The dairy barn is not modern and, while many improvements have been made since it was originally built, it is far from being satisfactory either for experimental purposes or for the production of the highest grade of sanitary milk. The light is not sufficient, the dirt floors are very difficult to keep clean and the ventilation is not always satisfactory. While it may not be advisable to spend much money in imroving this present barn, it is highly desirable that as soon as sufficient funds can be obtained a thoroughly practical and sanitary barn be constructed for experimental work.

The destruction of one of the herd bulls will necessitate the purchase of another at an early date to prevent in-breeding and to avoid overworking the one remaining.

Respectfully submitted,

T. I. MAIRS.

PRELIMINARY OBSERVATIONS ON PROTEIN SUPPLY OF DAIRY HERD.

BY THOS. I. MAIRS.

SUMMARY.

1. The cows fed the larger amount of protein produced more milk than those fed the smaller amount.
2. The mature cows of both lots, with two exceptions, did not vary much from their former records in milk production.
3. The cows fed the larger amount of protein ate more grain than those fed the smaller amount.
4. The cost of grain per hundred pounds was more for the grain mixture containing the larger amount of protein than for that containing the smaller amount.
5. The cost of milk per hundred pounds was more for the cows fed the larger amount of protein than for those fed the smaller amount.
6. The amount of protein in the feed had no perceptible effect upon the composition of the milk.
7. In general, the cows of both lots produced milk less rich in butterfat than the same cows produced in 1904.
8. The most marked difference between the two lots seemed to be in the greater amount of grain eaten by Lot II.
9. The chief advantage of the larger amount of protein fed, if any, seemed to be in stimulating the appetite, which induced the cows to eat more, and possibly resulted in the greater milk production.

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10. The difference on no point was marked enough to warrant its being attributed wholly to the feed.

As stated in an article in the Annual Report for 1904-5, at the beginning of the latter year an observation was begun on the effect of the amount of protein supplied in the food of dairy cows upon the production of milk and butter. This observation included the entire Experiment Station dairy herd and continued through the whole year. As stated in the former report, the herd consisted of thirty-four cows, three of which were registered Guernseys and the others grades of the same breed. The herd was divided into two lots approximately equal on the basis of butter production of 1904. One cow out of each of these lots was sold during the year making sixteen cows in each lot for the entire time.

The two lots were fed course fodder, silage and soiling crops exactly alike as far as possible. Soiling crops were fed *ad libitum* in season and, when not available, twenty pounds of corn silage and dry forage *ad libitum* were fed in their place. This dry forage consisted of shredded corn stover and mixed timothy and clover hay. Grain was fed according to the weight, appearance and performance of the individual, on the basis of eight pounds of grain for each twenty pounds of milk produced by a thousand pound cow. No cow was given more than twelve pounds of grain per day even though producing as much as forty pounds of milk. The grain was fed in equal lots morning and afternoon.

The grain for Lot I consisted of a mixture of six hundred pounds of corn meal and two hundred pounds of gluten feed. It was estimated that eight pounds of this mixture would contain as much protein as twenty pounds of average milk. The grain for Lot II consisted of a mixture of three hundred and fifty pounds of corn meal, two hundred and fifty pounds of gluten feed and two hundred pounds of cottonseed meal. It was estimated that one pound of this mixture would contain twice as much protein as an equal amount of the grain mixture fed to Lot I.

In this experiment it was assumed that the silage, soiling crops and dry fodder would furnish sufficient protein for the maintenance of the animal. The cows would thus have all the protein contained in the grain to apply to the production of milk. It was estimated that the protein contained in the grain fed to Lot I was equal to that turned out in the milk, while that contained in the grain fed to Lot II was just twice as much.

Samples of the grain used were drawn from time to time as new lots were mixed and these samples taken to the chemical laboratory for air drying and the determination of nitrogen. Composite samples of the milk of each cow were taken for five consecutive days at the close of each month for butter fat, nitrogen and specific gravity determination.

The weight of the cows was taken on three consecutive days at the beginning of each month. The average of these three weighings was assumed to be the weight of the cows at the opening of the month. In the article above mentioned is given a table of the age and weight of the different cows January 1, 1905. From this table it is seen that the two lots were practically equal in these respects.

Tables I to VII, following, give the records of the entire herd for the last seven months of 1905. The records for the first five

months of this year are given in the former article as above stated. These tables include only the records of such cows as were being milked during the entire month. Cows which went dry or came fresh during any month are not included in the record for that month. The records of the individual cows are averaged for each lot.

Table I.—June, 1905.

	Days from calving.	Grain eaten. Lbs.	Milk. Lbs.	Butter Fat.		Protein. Per cent.	Gain in live weight. Lbs.
				Per cent.	Pounds.		
Lot I.							
Dixie,	198	180	492.9	4.7	23.2	3.36	—4
Kit,	84	180	708.7	4.1	28.4	3.04	—18
Sis,	Dry	.....	.....	.....	.....	.....	.....
Rose,	Dry	.....	.....	.....	.....	.....	.....
Tease,	349	150	424.7	3.85	16.4	3.61	—8
Lucretia,	241	120	153.3	5.0	7.7	4.32	17
Mary,	Dry	.....	.....	.....	.....	.....	.....
Countess,	210	120	243.2	4.65	11.3	3.75	—32
Clio,	Dry	.....	.....	.....	.....	.....	.....
Laurel,	164	120	380.3	4.25	16.2	3.19	—2
Sister,	129	150	350.6	4.4	15.4	3.38	—6
Petty,	96	225	508.7	4.6	23.4	3.43	—30
Cibola,	188	201	593.7	4.6	27.3	3.39	3
Sally,	248	120	272.0	3.35	9.1	3.11	5
Lena,	251	120	230.2	5.1	11.7	3.85	24
Ramona,	68	106	576.9	3.2	18.5	2.63	—13
Total,	2,223	1,792	4,935.2	.....	208.6	.....	—64
Average,	185.5	149.3	411.3	4.23	17.4	3.23	—5.3
Lot II.							
Cena,	121	240	626.8	4.2	26.3	2.83	11
Maria,	Dry	.....	.....	.....	.....	.....	.....
Tops,	271	195	457.6	4.7	21.5	3.49	17
Sue,	Dry	.....	.....	.....	.....	.....	.....
Lassie,	Dry	.....	.....	.....	.....	.....	.....
Jess,	110	230	800.5	3.75	30.0	3.11	—30
Sweetness,	105	330	794.9	3.85	30.6	3.20	15
Flovina,	172	120	294.1	4.0	11.8	3.38	—8
Ruth,	191	187.5	561.1	4.15	23.4	3.40	1
Niobe,	110	240	569.2	4.2	23.9	3.55	—28
Viola,	287	150	326.1	4.6	15.0	3.66	7
Sybil,	Dry	.....	.....	.....	.....	.....	.....
Avina,	139	210	448.8	4.6	20.6	3.29	—18
May,	117	180	344.4	5.55	19.1	3.69	—25
Jolly,	28	270	751.4	4.55	34.2	3.18	—32
Titia,	225	195	588.6	4.15	24.4	3.24	—7
Total,	1,876	2,647.5	6,563.5	.....	280.8	.....	—97
Average,	156.3	220.6	547.0	4.27	23.4	3.26	—8.1

The sign + indicates a gain.
The sign — indicates a loss.

Table II.—July, 1905.

	Days from calving.	Grain eaten. Lbs.	Milk. Lbs.	Butter Fat. Per cent.	Butter Fat. Pounds.	Protein. Per cent.	Gain in live weight. Lbs.
Lot I.							
Dixie,	228	186	367.2	5.6	20.6	3.41	25
Kit,	114	186	610.2	4.4	26.9	3.19	17
Sis,	Dry	.....	.....	.....	.....	.....	.....
Rose,	Dry	.....	.....	.....	.....	.....	.....
Tease,	379	162	462.4	4.6	18.5	3.53	—18
Lucretia,	Dry	.....	.....	.....	.....	.....	.....
Mary,	Dry	.....	.....	.....	.....	.....	.....
Countess,	240	93	146.9	6.05	8.9	3.94	—15
Clio,	Dry	.....	.....	.....	.....	.....	.....
Laurel,	194	139.5	326.6	5.7	18.6	3.34	11
Sister,	159	124	257.8	5.0	12.9	3.49	7
Petty,	126	201.5	486.1	4.8	23.3	3.44	17
Cibola,	218	196	491.1	4.65	22.8	3.49	—4
Sally,	278	77.5	158.7	5.55	8.8	3.19	22
Lena,	Dry	.....	.....	.....	.....	.....	.....
Ramona,	98	93	457.4	3.5	16.0	2.73	46
Total,	2,034	1,458.5	3,704.4	.....	177.3	.....	+108
Average,	203.4	145.9	370.4	4.79	17.7	3.30	+9.8
Lot II.							
Cena,	151	248	520.0	5.1	26.5	2.94	—6
Maria,	6	252.5	917.2	.....	38.1	2.91	—31
Tops,	301	155	272.0	5.15	14.0	3.57	21
Sue,	Dry	.....	.....	.....	.....	.....	.....
Lassie,	Dry	.....	.....	.....	.....	.....	.....
Jess,	140	310	725.3	4.2	30.5	3.11	18
Sweetness,	135	279	662.3	4.15	27.5	3.14	—23
Flovina,	202	124	217.3	4.45	9.7	3.57	27
Ruth,	221	154	321.4	4.8	15.4	3.43	8
Niobe,	140	232.5	526.1	4.65	24.5	3.42	20
Viola,	317	124	210.6	5.75	12.1	4.06	15
Sybil,	6	209	726.2	4.35	31.6	3.06	—5
Avina,	169	170.5	396.9	4.8	19.1	3.26	21
May,	147	108.5	251.4	5.5	14.2	3.64	5
Jolly,	58	279	663.6	5.0	33.2	3.10	1
Titia,	255	186	421.8	4.55	19.2	3.43	5
Total,	2,248	2,832	6,832.1	.....	315.6	.....	+76
Average,	160.6	202.3	488.0	4.62	22.5	3.22	+5.4

Table III.—August, 1905.

Lot I.							
Dixie,	Dry	.....	.....	.....	.....	.....	.....
Kit,	145	187	575.7	4.7	27.1	3.19	—19
Sis,	25	361.5	939.6	3.6	33.8	3.06	—22
Rose,	10	285	790.3	4.1	31.8	3.41	—41
Tease,	410	155	377.9	4.5	17.0	3.25	2
Lucretia,	Dry	.....	.....	.....	.....	.....	.....
Mary,	Dry	.....	.....	.....	.....	.....	.....
Countess,	Dry	.....	.....	.....	.....	.....	.....
Clio,	24	279	602.7	4.9	29.5	3.91	7
Laurel,	225	124	248.5	6.5	16.2	3.46	9
Sister,	190	93	114.3	5.8	6.6	4.24	12
Petty,	157	186	371.2	5.2	19.3	3.41	—2
Cibola,	249	155	374.3	6.2	23.2	3.51	—37
Sally,	Dry	.....	.....	.....	.....	.....	.....
Lena,	Dry	.....	.....	.....	.....	.....	.....
Ramona,	129	93	386.2	4.3	16.6	2.99	—23
Total,	1,561	1,918.5	4,780.7	.....	224.1	.....	111
Average,	156.1	191.9	478.1	4.68	22.4	3.23	—11.1

The sign + indicates a gain.
The sign — indicates a loss.

Table III.—Continued.

	Days from calving.	Grain eaten. Lbs.	Milk. Lbs.	Butter Fat. Per cent.	Butter Fat. Pounds.	Protein. Per cent.	Gain in live weight. Lbs.
Lot II.							
Cena,	182	217	442.8	4.6	20.4	2.89	—19
Maria,	37	349	942.4	3.6	33.9	3.05	—15
Tops,	332	93	157.5	5.5	8.7	4.04	—11
Sue,	5	210.5	810.1	4.3	34.9	3.09	.....
Lassie,	4	232.5	680.6	4.8	32.7	3.21	.....
Jess,	171	279	662.5	4.4	29.2	3.49	—32
Sweetness,	166	279	628.1	4.4	27.6	3.68	17
Flovina,	233	93	162.9	4.8	7.8	3.39	—1
Ruth,	252	124	250.9	6.2	15.6	3.95	34
Niobe,	171	217	495.4	5.0	24.8	3.48	3
Viola,	Dry	.....	.....	.....	.....	.....	.....
Sybil,	37	279	644.2	4.6	29.6	3.16	6
Avina,	200	130	243.3	4.7	11.4	3.73	6
May,	178	93	178.3	6.2	11.1	3.56	—27
Jolly,	89	248	579.4	5.0	29.0	3.14	—20
Titia,	286	155	252.3	5.2	13.1	4.34	40
Total,	2,343	2,999	7,130.7	.....	329.8	.....	—19
Average,	156.2	199.9	475.4	4.62	21.9	3.30	—1.3

Table IV.—September, 1905.

Lot I.							
Dixie,	Dry	.....	.....	.....	.....	.....	.....
Kit,	176	180	511.6	4.9	25.1	3.66	12
Sis,	56	300	761.8	4.0	30.5	3.18	—10
Rose,	41	270	676.9	4.65	31.5	3.42	15
Tease,	441	133	342.5	4.3	14.7	3.89	—6
Lucretia,	.....	247	737.8	4.2	29.5	3.14	.....
Mary,	4	258.5	704.3	4.2	29.6	3.34	.....
Countess,	Dry	.....	.....	.....	.....	.....	.....
Clio,	55	219	445.9	4.75	21.2	3.63	50
Laurel,	256	103	154.4	.....	10.0	3.65	32
Sister,	Dry	.....	.....	.....	.....	.....	.....
Petty,	188	146	236.8	6.15	14.6	4.24	26
Cibola,	Dry	.....	.....	.....	.....	.....	.....
Sally,	18	191.5	433.7	4.15	18.0	3.13	28
Lena,	12	295	718.7	3.75	27.0	3.09	30
Ramona,	160	102.5	327.0	4.00	13.1	3.28	23
Total,	1,407	2,445.5	6,651.4	.....	264.8	.....	200
Average,	117.3	203.8	504.3	4.37	22.1	3.38	+16.7
Lot II.							
Cena,	213	159	299.7	4.65	13.9	3.59	30
Maria,	68	300	779.9	3.95	30.8	3.59	25
Tops,	Dry	.....	.....	.....	.....	.....	.....
Sue,	36	274.5	721.2	4.05	29.2	3.51	—48
Lassie,	35	268	611.6	4.8	29.4	3.74	53
Jess,	202	253	568.9	4.15	23.6	3.70	32
Sweetness,	197	253	509.9	4.35	22.2	3.69	33
Flovina,	264	73	92.6	4.3	4.0	3.52	—12
Ruth,	Dry	44	.....	.....	.....	.....	.....
Niobe,	202	193	400.3	4.85	19.4	4.02	33
Viola,	Dry	.....	.....	.....	.....	.....	.....
Sybil,	68	253	534.0	4.4	23.5	3.24	6
Avina,	Dry	.....	.....	.....	.....	.....	.....
May,	209	73	150.2	6.3	9.5	4.03	.....
Jolly,	120	206	457.4	5.3	24.2	3.48	11
Titia,	Dry	.....	.....	.....	.....	.....	.....
Total,	1,614	2,305.5	5,125.7	.....	229.7	.....	+163
Average,	146.7	209.6	466.0	4.48	20.9	3.63	+14.8

The sign + indicates a gain.
The sign — indicates a loss.

Table V.—October, 1905.

	Days from calving.	Grain eaten. Lbs.	Milk. Lbs.	Butter Fat. Per cent.	Butter Fat. Pounds.	Protein. Per cent.	Gain in live weight. Lbs.
Lot I.							
Dixie,	.....	208.5	621.1	4.2	26.1	3.46	.....
Kit,	206	186	549.1	4.8	26.4	3.66	56
Sis,	86	310	801.3	4.1	32.9	3.31	42
Rose,	71	279	702.4	5.0	33.7	3.75	10
Tease,	471	124	374.3	4.3	16.1	3.76	17
Lucretia,	30	293	871.2	4.3	37.5	3.31	12
Mary,	34	291.3	734.7	4.0	29.4	3.78	65
Countess,	5	170	592.8	3.8	22.5	3.24	.....
Clio,	85	186	413.6	5.4	22.3	3.59	—8
Laurel,	Dry	.....	.....	.....	.....	.....	.....
Sister,	Dry	.....	.....	.....	.....	.....	.....
Petty,	218	124	193.4	5.8	11.2	4.24	61
Cibola,	Dry	.....	.....	.....	.....	.....	.....
Sally,	48	147.5	431.9	4.6	19.9	3.30	44
Lena,	42	310	705.1	4.5	31.7	3.34	33
Ramona,	190	93	390.6	4.0	15.6	3.18	53
Total,	1,486	2,722.3	7,381.5	.....	325.3	.....	385
Average,	114.35	209.4	567.8	4.41	25.0	3.48	+29.6
Lot II.							
Cena,	243	124	242.8	4.8	11.7	3.83	35
Maria,	98	310	803.0	4.2	33.7	3.39	26
Tops,	Dry	.....	.....	.....	.....	.....	.....
Sue,	66	310	730.1	4.6	33.6	3.66	31
Lassie,	65	279	693.9	5.2	36.1	3.69	22
Jess,	232	248	527.9	5.1	26.9	4.45	45
Sweetness,	227	248	471.3	5.1	24.0	3.81	34
Flovinia,	294	62	129.1	4.6	5.9	3.70	25
Ruth,	Dry	.....	.....	.....	.....	.....	.....
Niobe,	232	186	370.0	5.1	18.9	3.81	25
Viola,	26	248	620.0	4.35	27.0	3.38	13
Sybil,	98	248	602.7	4.9	29.5	3.33	25
Avina,	Dry	.....	.....	.....	.....	.....	.....
May,	239	62	203.9	6.1	12.4	3.85	16
Jolly,	150	186	460.2	5.4	24.9	3.70	14
Titia,	Dry	.....	.....	.....	.....	.....	.....
Total,	1,970	2,511.0	5,854.9	.....	284.6	.....	311
Average,	147.5	209.3	487.9	4.86	23.7	3.67	+25.9

Table VI.—November, 1905.

Lot I.							
Dixie,	31	229.5	614.4	4.7	28.9	3.75	27
Kit,	237	180	448.1	5.45	24.4	3.66	28
Sis,	117	300	711.4	4.6	32.7	3.66	9
Rose,	102	227.5	568.3	5.2	29.0	3.94	1
Tease,	502	120	312.3	4.8	15.0	4.38	7
Lucretia,	61	300	737.6	4.8	35.4	3.63	2
Mary,	65	300	628.1	4.7	29.5	4.00	18
Countess,	36	238.5	531.1	4.8	25.5	3.50	49
Clio,	116	180	347.3	5.2	18.1	3.78	38
Laurel,	Dry	.....	.....	.....	.....	.....	.....
Sister,	Dry	.....	.....	.....	.....	.....	.....
Petty,	Dry	.....	.....	.....	.....	.....	.....
Cibola,	6	270.5	853.3	4.1	35.0	3.66	.....
Sally,	79	210	422.6	4.7	19.9	3.50	28
Lena,	73	300	615.5	4.5	27.7	3.53	16
Ramona,	221	90	351.9	4.2	14.8	3.38	17
Total,	1,646	2,946	1,131.9	.....	335.9	.....	240
Average,	126.6	226.6	548.6	4.71	25.8	3.63	+18.5

The sign + indicates a gain.
The sign − indicates a loss.

Table VI.—Continued.

	Days from calving.	Grain eaten. Lbs.	Milk. Lbs.	Butter Fat. Per cent.	Butter Fat. Pounds.	Protein. Per cent.	Gain in live weight. Lbs.
Lot II.							
Cena,	Dry	.....	.....	.....	.....	.....	.....
Maria,	129	300	727.4	4.4	32.0	3.63	10
Tops,	21	300	861.0	4.6	39.6	3.38	30
Sue,	97	300	587.6	4.6	27.0	4.19	51
Lassie,	96	270	637.5	5.6	35.7	4.00	14
Jess,	263	240	296.4	4.9	14.5	5.47	55
Sweetness,	258	240	352.1	4.5	15.8	3.78	52
Flovina,	325	60	87.0	4.2	3.7	3.97	38
Ruth,	3	265	842.6	3.65	30.8	3.03	.....
Niobe,	263	180	270.4	5.0	13.5	4.50	37
Viola,	57	240	508.1	4.7	23.9	3.66	23
Sybil,	129	240	521.6	4.65	24.3	3.53	46
Avina,	Dry	.....	.....	.....	.....	.....	.....
May,	270	80	184.4	6.2	11.4	4.25	24
Jolly,	181	180	342.1	5.5	18.8	3.78	3
Titia,	22	300	986.5	3.75	37.0	3.22	6
Total,	2,114	3,195	7,204.7	.....	328.0	.....	389
Average,	151	228.2	514.6	4.55	23.4	3.68	+29.9

Table VII.—December, 1905.

Lot I.							
Dixie,	61	217	508.8	5.0	25.4	3.75	17
Kit,	267	186	346.3	5.1	17.7	4.25	24
Sis,	147	292.5	636.6	4.4	28.0	3.44	—5
Rose,	132	217	486.2	5.2	25.3	3.88	21
Tease,	532	124	255.2	4.5	11.5	4.31	11
Lucretia,	91	310	669.8	4.6	30.8	3.47	11
Mary,	95	310	550.9	4.9	27.0	3.94	—10
Countess,	66	279	500.9	4.9	24.5	3.72	9
Clio,	136	186	327.5	5.7	18.7	3.81	9
Laurel,	15	300	640.8	5.5	35.2	3.66	10
Sister,	6	272.5	599.9	4.1	24.6	3.25	.....
Petty,	Dry	.....	.....	.....	.....	.....	.....
Cibola,	36	310	799.6	4.3	34.4	3.06	22
Sally,	109	217	431.4	4.7	20.3	3.53	7
Lena,	103	310	595.8	4.7	28.0	3.72	24
Ramona,	251	93	297.6	4.1	12.2	3.50	8
Total,	2,047	3,624	7,647.3	.....	363.6	.....	158
Average,	136.5	241.6	509.8	4.75	24.2	3.62	+10.5
Lot II.							
Cena,	Dry	.....	.....	.....	.....	.....	.....
Maria,	159	310	691.8	4.5	31.1	3.75	5
Tops,	51	310	821.9	4.7	38.6	3.41	5
Sue,	127	310	462.2	4.5	20.8	4.31	12
Lassie,	126	279	596.3	5.4	32.2	4.00	—7
Jess,	293	186	114.1	5.0	15.7	6.38	43
Sweetness,	288	248	307.7	5.1	5.7	4.38	21
Flovina,	Dry	.....	.....	.....	.....	.....	.....
Ruth,	33	333	940.5	3.5	32.9	3.03	26
Niobe,	293	186	161.6	5.3	8.6	5.84	49
Viola,	87	248	484.3	4.8	23.3	3.94	10
Sybil,	159	248	474.7	5.2	24.7	3.75	31
Avina,	Dry	.....	.....	.....	.....	.....	.....
May,	300	124	188.6	6.2	11.7	4.50	25
Jolly,	211	186	325.0	5.5	17.9	4.03	18
Titia,	52	310	910.2	3.9	35.5	3.31	11
Total,	2,179	3,278	6,478.9	.....	298.7	.....	249
Average,	167.6	252.2	499.1	4.63	23.0	3.78	+19.2

From these tables it is seen that except for the month of October the cows of Lot II ate uniformly more grain than those of

The sign + indicates a gain.
The sign — indicates a loss.

Lot I. During this month the average amount of grain eaten by the two lots was practically the same. During five of these seven months the cows of Lot I produced on the average more milk than those of Lot II. During four of the seven months the milk from Lot I was richer in butter fat than that from Lot II. During six of the seven months the milk of Lot II was richer in protein than that of Lot I. During the months of June and September the milk of practically the entire herd seemed to be unusually low in butter fat content. The only month which showed a distinct difference in the butter fat content of the two lots was October. The difference in protein content was marked only in the months of September and October, and even then it was not great. During four of these months the cows of Lot I made greater gains in live weight than those of Lot II. These tables do not show any greater variation than is shown by herds in general which are fed uniformly.

Table VIII.—Milk and Butter Fat Produced in 1904 and 1905, and Grain Eaten in 1905.

	1904.		1905.		
	Milk. Lbs.	Butterfat. Lbs.	Milk. Lbs.	Butterfat. Lbs.	Grain eaten. Lbs.
Lot I.					
Dixie,	5,463.0	302.6	6,159.7	316.3	2,417.5
Kit,	5,650.2	315.7	5,988.6	281.9	1,921.0
Sis,	6,202.0	312.9	6,509.6	283.5	2,773.3
Rose,	5,532.2	301.7	5,730.8	293.0	2,365.5
Tease,	5,796.6	250.5	4,950.0	221.9	2,052.3
Lucretia,	5,047.2	254.1	5,853.5	278.0	2,471.5
Mary,	5,501.8	288.3	5,126.8	249.6	2,362.3
Countess,	4,828.7	252.7	4,276.1	210.6	1,807.5
Clio,	5,100.4	275.2	4,189.5	222.0	1,977.0
Laurel,	4,544.5	269.0	4,446.6	249.7	1,717.5
Sister,	4,099.4	223.5	3,845.7	172.8	1,576.5
Petty,	.....	.....	4,064.6	202.5	1,919.5
Cibola,	.....	.....	6,361.6	294.7	2,407.5
Sally,	.....	.....	4,435.0	208.9	1,721.3
Lena,	.....	.....	4,934.1	229.1	2,259.0
Ramona,	6,155.3	276.9	4,144.0	171.2	942.0
Total,	63,921.3	3,323.1	81,016.2	3,885.7	32,691.2
Average,	5,326.8	276.9	5,063.5	242.9	2,043.2
Average, 12,	.....	.....	5,101.7	245.9	.....
Lot II.					
Cena,	5,397.2	266.6	5,729.2	254.2	2,167.8
Marla,	7,098.1	322.8	7,398.7	322.7	2,854.5
Tops,	5,964.8	293.3	6,373.9	304.7	2,479.0
Sue,	5,270.2	243.5	5,317.7	244.5	2,516.0
Lassie,	5,313.2	297.8	5,758.5	314.8	2,547.0
Jess,	4,651.2	212.8	7,185.6	298.4	3,104.3
Sweetness,	7,017.6	352.0	7,067.1	310.9	3,093.0
Flovina,	3,986.2	186.4	4,429.6	207.7	1,754.0
Ruth,	6,879.0	300.4	6,652.2	272.1	2,425.0
Niobe,	5,861.9	282.2	5,663.4	263.5	2,506.0
Viola,	4,834.7	254.3	4,774.6	236.6	2,143.8
Sybil,	6,079.8	302.3	5,539.3	272.6	2,346.3
Alvina,	4,714.9	242.4	4,740.7	219.5	2,016.5
May,	4,136.5	245.9	3,637.2	205.2	1,777.0
Jolly,	.....	.....	4,941.3	236.2	2,196.5
Tilla,	.....	.....	7,187.6	293.6	2,667.5
Total,	77,205.2	3,802.7	92,396.6	4,277.2	38,554.2
Average,	5,514.7	271.6	5,774.8	267.3	2,409.6
Average, 14,	.....	.....	5,733.4	266.2	.....

Table VIII gives the milk and butter record of the individual cows for the years 1904-5 and the grain eaten in 1905. From this

table it is seen that twelve cows from Lot I and fourteen cows from Lot II were milking during practically the entire year of 1904. The average of the twelve cows of Lot I for this year was 5,326.8 pounds of milk and 276.9 pounds of butter fat. The average production of the fourteen cows of Lot II was 5,514.7 pounds of milk and 271.6 pounds of butter fat from the same period. In 1905 the twelve cows of Lot I produced an average of 5,101.7 pounds of milk and 245.9 pounds of butter fat, while the fourteen cows of Lot II produced 5,733.4 pounds of milk and 266.2 pounds of butter fat. Thus it is seen that, while the average milk production of Lot I fell off about two hundred pounds, that of Lot II was increased about the same amount. If, however, one cow be taken out of each lot, the cow, Ramona, out of Lot I because she was sick and off feed part of the year, and the cow, Jess, out of Lot II because she was dry during a considerable portion of 1904, it is found that the milk production for the two years was much more nearly equal. That is, Lot I fell off only 62.7 pounds per cow and Lot II increased only 41.6 pounds per cow. Five cows in Lot I produced more milk in 1905 than in 1904. These were all mature cows and the increase could not have been from their immaturity the preceding year. Nine cows of Lot II produced more milk during 1905 than during 1904; two of the nine, however, produced practically the same each year. Only two cows in Lot I produced more butter fat in 1905 than they did in 1904. Five cows in Lot II produced more butter fat in 1905 than they did in 1904. It must be remembered that Lot II contained two more cows with records for 1904 than Lot I contained. Neither of the two lots produced as much butter fat in 1905 as the same cows did in 1904. The cows of Lot II ate 366 pounds more grain per head during the year than those of Lot I.

The question arises whether the increased production of Lot II resulted from the increased amount of grain eaten or from the higher protein content of the grain. The question also arises whether the larger amount of grain eaten by Lot II was the result of normally greater appetites possessed by the cows of this lot or of the greater palatibility of the grain mixture. If the latter; did the greater palatability of the grain mixture result from the greater protein content or from the larger number of ingredients in the mixture, or from the cottonseed meal?

Table IX.—Summary of Results for the Year.

	1904.		1905.	
	Lot I.	Lot II.	Lot I.	Lot II.
Average pounds milk,*	5,326.8	5,514.7	5,101.7	5,733.4
Average pounds milk, all cows,	.....	.....	5,063.5	5,774.3
Average pounds butterfat,*	276.9	271.2	245.9	266.3
Average pounds butterfat, all cows,	.....	.....	242.9	267.3
Average per cent. butterfat,*	5.20	4.92	4.80	4.65
Average per cent. butterfat, all cows,	.....	.....	4.80	4.63
Average pounds grain eaten,	.....	.....	2,043.2	2,409.6
Average pounds grain per pound butterfat,	.....	.....	8.41	9.01
Average pounds grain per 100 pounds milk,	.....	.....	40.35	41.73
†Cost of grain per pound butterfat,	.....	.....	9.34	10.45
†Cost of grain per 100 pounds milk,	.....	.....	44.79	48.41
†Cost of grain per head,	.....	.....	$22.68	$27.95

*Twelve cows in Lot I and 14 cows in Lot II.

†Assuming corn meal to cost $22 per ton, gluten feed $23 per ton and cottonseed meal $26 per ton.

Table IX is a summary of the results for the year. In addition to the results already noted, it shows that Lot I ate 8.41 pounds of grain costing 9.34 cents for each pound of butter fat produced, while Lot II ate 9.01 pounds of grain, costing 10.45 cents for the same production. Lot I ate 40.35 pounds of grain costing 44.79 cents for each 100 pounds of milk produced, while Lot II ate 41.73 pounds of grain costing 48.41 cents for the same amount of milk produced. The average cost of grain for the cows of Lot I for the year was $22.68, of Lot II $27.95. These figures assume that the cost of corn meal was $22.00 per ton, gluten feed $23.00 per ton and cotton seed meal $26.00 per ton, which was about their actual price when the experiment was planned.

Supposing the silage and coarse fodder eaten by the two lots to have been equal and the milk to have been worth one cent per pound, Lot II made a greater profit than Lot I. If the milk were worth more than one cent per pound, the difference in favor of Lot II would be greater.

Again, supposing the silage and coarse fodder eaten by the two lots to have been equal, on the basis of butter fat at 20 cents per pound, the profits from Lot I were greater; on the basis of butter fat at 25 cents per pound, the profits from Lot II were greater. The relative economy of the two rations would largely depend upon the price obtained for the product.

It is possible that the price given for cornmeal is too high in comparison with the prices of the other concentrates. If so, the showing would be more in favor of Lot 1, that is, there would be a grain mixture fed daily equal to two-fifths the weight of the milk produced.

A COMPARISON OF ALFALFA MEAL AND WHEAT BRAN FOR DAIRY COWS.

BY THOS. I. MAIRS.

SUMMARY.

1. The alfalfa meal contained 15.48 per cent. protein, the wheat bran contained 16.95 per cent. protein.

2. The results of this test do not warrant the recommendation of alfalfa meal as a substitute for wheat bran as a feed for dairy cows at the present market prices, for the following reasons:

(a) The alfalfa meal was less palatable and resulted in a decreased milk production in every case.

(b) The alfalfa meal in Central Pennsylvania costs approximately $23 per ton, whereas good winter wheat bran could be had for $20 per ton or less.

(c) Assuming the alfalfa meal to cost $23 per ton, corn and cob meal $20 per ton, wheat bran $20 per ton and cottonseed meal $28 per ton, the grain cost of one hundred pounds of milk when the cows were fed alfalfa meal was 47.1 cents, when fed wheat bran it was 45.3 cents.

3. Assuming alfalfa meal to cost no more than bran, viz: $20 per ton, the former seemed to produce milk at the lower grain cost per 100 pounds, viz: 44 cents as compared with 45.3 cents on bran. On the basis of comparison, if wheat bran was worth $20 per ton, alfalfa meal was worth $21.28.

4. Ignoring the last period, however, during a part of which no silage was fed, the cost of the bran ration was 43.9 cents per hundred pounds of milk produced, against 44 cents for alfalfa meal at the same price per ton.

The extensive advertising which has been given to alfalfa meal as a substitute for wheat bran during the last few years has seemed to warrant a comparison of the merits of the two. Alfalfa meal has been recommended widely as a source of protein in home mixed rations and has also been used to a large extent as the basis of many proprietary or semi-proprietary feeds.

It is alfalfa hay ground to about the fineness of wheat bran. The object in grinding is to permit of its being readily mixed with the grain ration. A large demand for this feed may result in grinding the poorer grades of alfalfa that cannot be readily sold as hay. The lot used in this experiment was undoubtedly made of a good grade of hay, as was shown by its color and its high protein content.

In order to compare the relative merits of alfalfa meal and wheat bran for milk and butter production, ten cows of the Station herd which were in practically full flow of milk were divided into two lots as nearly equal as possible on the basis of milk production, age and stage of lactation. For roughage both lots received corn silage and mixed hay during the entire experiment, except toward the close of the fourth period as noted later. The grain ration consisted of corn meal, cottonseed meal and alfalfa meal in one case and in the other of corn meal, cottonseed meal and wheat bran, the proportions being corn meal, three parts, cottonseed meal, one part, and wheat bran or alfalfa meal, four parts. Since alfalfa meal has been most extensively recommended to take the place of wheat bran it was thought best to substitute the one for the other pound for pound. The experiment was divided into four periods of three weeks each. During the first and last period the two lots were fed exactly alike on the ration containing wheat bran. During the second period the two lots were fed exactly alike except that Lot I was fed the ration containing alfalfa meal, while Lot II was continued on wheat bran. During the third period these rations were reversed, Lot I being fed wheat bran and Lot II alfalfa meal. The following scheme shows the feeding by periods and rations.

	First Period.	Second Period.	Third Period.	Fourth Period.
Lot I, ...	Wheat bran, ...	Alfalfa meal, ...	Wheat bran, ...	Wheat bran.
Lot II, ...	Wheat bran, ...	Wheat bran, ...	Alfalfa meal, ...	Wheat bran.

The ten cows stood in a row of stalls side by side. They were fed in such manner and at such times as had been the custom, namely, the grain in equal portions about 5 A. M. and about 4

P. M., the hay about 6 A. M. and the silage about 5 P. M. The feeding was based upon the following as a ration for a 1,000 pound cow giving 20 pounds of milk per day. This ration was varied to suit the individual cow, the intention being to have the weight of the grain mixture fed daily equal to two-fifths the weight of the milk produced.

Corn Silage, 30 pounds.
Mixed hay, 12 pounds.
Corn meal, 3 pounds.
Cottonseed meal, 1 pound.
Wheat bran or alfalfa meal, 4 pounds.

The daily ration of hay was weighed for each cow separately and was placed in bags for one week in advance. The silage for each cow was weighed daily. The grain ration was mixed in advance for each lot for an entire period and placed in bins set aside for the purpose. The grain mixture was weighed to each cow as fed. The feed was all sampled for determination of air-dry matter and protein. The milk was sampled as weighed, weekly composite samples being taken for determination of butter fat and specific gravity.

The cows were weighed for three consecutive days at the beginning of each period and at the end of the last period, the weighing being at the same hour each day, and in the same order, after having been off water for 24 hours. The following table shows the names of the cows with their ages and their weights at the beginning of each period and at the close of the last, with the date of calving and the days from calving at the beginning of the experiment, January 30. By reference to this table it will be seen that there was a constant gain in live weight during the entire experiment.

Table 1.—Weight of Cows.

Name.	Age.	Beginning of Period I.	Beginning of Period II.	Beginning of Period III.	Beginning of Period IV.	Close of Period IV.	Date of calving.	Days from calving.
Dixie,	8	971	996	1,019	1,038	1,055	Oct. 1, 1905,	121
Lucretia,	7	1,007	1,037	1,076	1,106	1,123	Sept. 25, 1905,	152
Cibola,	4	816	827	861	871	876	Oct. 1, 1905,	96
Ruth,	5	788	803	805	825	830	Oct. 28, 1905,	93
Viola,	4	677	697	710	729	734	Sept. 4, 1905,	148
Total,	.....	4,259	4,360	4,471	4,569	4,618	.....	610
Average,	.....	852	872	894	914	924	.....	122
Tops,	7	896	903	911	942	952	Oct. 10, 1905,	111
Titia,	4	796	784	804	823	838	Oct. 9, 1905,	110
Mary,	7	928	940	949	978	966	Aug. 27, 1905,	156
Countess,	5	877	857	898	929	925	Sept. 25, 1905,	127
Laurel,	4	818	827	843	857	857	Nov. 15, 1905,	75
Total,	.....	4,315	4,311	4,405	4,529	4,538	.....	579
Average,	.....	863	862	881	906	908	.....	116

The following table gives the amount of feed eaten by the individual cows for each period.

Table 2.—Feed Eaten by Individual Cows.

Cow.	Grain.				Ensilage.				Hay.			
	Period I.	Period II.	Period III.	Period IV.	Period I.	Period II.	Period III.	Period IV.	Period I.	Period II.	Period III.	Period IV.
Dixie,	168	124	147	147	630	625.5	630	480	266	294	294	368.5
Lucretia,	189	189	189	189	630	630	630	480	266	294	287.3	367.8
Cibola,	189	189	189	189	630	630	630	480	251	252	251	294
Ruth,	210	199	189	189	630	610	588	448	252	252	246	283.3
Viola,	126	126	126	126	422.5	420	420	320	221.3	210	209.5	242.5
Total,	882	827	840	840	2,942.5	2,915.5	2,898	2,208	1,256.3	1,302	1,287.8	1,556.1
Average,	176.4	165.4	168	168	588.5	583.1	579.4	441.6	251.3	260.4	257.6	311.2
Tops,	210	210	191	189	630	630	630	480	266	294	291	342
Titia,	210	210	193.3	189	630	630	630	480	244.5	191.5	164.8	211.3
Mary,	168	168	168	168	518	603	588	448	251	252	249.8	295
Countess,	147	147	147	147	630	630	630	480	252	252	252	302.5
Laurel,	168	126	87	125	630	630	630	480	252	252	246.5	298.5
Total,	903	861	786.3	818	3,038	3,123	3,108	2,368	1,265.5	1,241.5	1,204.1	1,449.3
Average,	180.6	172.2	157.3	163.6	607.6	624.6	621.6	473.6	253.1	248.3	240.8	289.9

The ration containing the alfalfa meal did not seem to be eaten as readily as that containing the wheat bran. By reference to this table it will be seen that the cows, Dixie, Tops, Titia and Laurel ate less grain when on the alfalfa ration than in either the preceding or following period on the bran ration. On the other hand, no cow ate more of the alfalfa ration than of the bran ration. The smaller amount of silage eaten by the cows during the fourth period and the larger amount of hay eaten during that time are due to the fact that the silage ran out about two weeks before the close of the period. After this mixed hay (timothy and clover) was substituted for the corn silage. In making substitutions it was assumed that one pound of hay was equivalent to three pounds of silage. When the experiment was first planned it was contemplated to feed all the cows equal portions of hay and silage and vary the grain ration only. This, however, was soon found to be impracticable owing to the difference in the size of the animals, and the peculiarities of their appetites.

Table 3 shows the milk production of the different cows by periods.

Table 3.—Milk Production by Periods.

Cow.	Period I. Jan. 30-Feb. 19.	Period II. Feb. 20-Mar. 12.	Period III. Mar. 13-Apr. 2.	Period IV. Apr. 3-Apr. 23.
Dixie,	380.9	324.9	354.2	355.7
Lucretia,	421.2	388.5	353.6	314.4
Cibola,	490.0	470.0	464.8	455.3
Ruth,	553.1	520.8	500.7	470.4
Viola,	311.1	287.7	284.3	251.7
Total,	2,156.3	1,991.9	1,597.6	1,847.5
Decrease,	.....	164.4	34.3	110.1
Tops,	523.2	526.7	468.4	453.5
Titia,	545.2	533.0	494.5	462.4
Mary,	364.0	365.4	300.6	273.5
Countess,	339.4	334.9	304.5	277.8
Laurel,	349.0	333.2	294.1	292.2
Total,	2,120.8	2,093.2	1,862.1	1,759.4
Decrease,	.....	27.6	231.1	102.7
Difference,	35.5	*101.3	95.5	88.1

*Difference in favor of Lot II; in other periods in favor of Lot I.

During the first period, when both lots were fed practically alike, Lot I produced a total of 35.5 pounds more milk than Lot II. During the second period when Lot I was fed the ration containing the alfalfa meal it is seen that Lot II produced 101.3 pounds more than Lot I. Both lots, however, fell off slightly in total milk production. Lot I falling off 164.4, while Lot II fell off only 22.6 pounds. During the third period when Lot I was changed back to the bran ration and Lot II was put on the alfalfa ration Lot I fell off only 34.3 while Lot II fell off 231.1 pounds. During the fourth period when both lots were again on the bran ration Lot I fell off 110.1 pounds while Lot II fell off 102.7 pounds. During the third

period Lot I produced a total of 95.5 pounds more milk than Lot II. During the fourth period it produced 88.1 pounds more. It is thus seen that the cows on alfalfa meal fell in milk production in both cases more rapidly than those on wheat bran. All of the cows gave less milk during the three weeks they were on alfalfa meal than on the average of the preceding and following three weeks on bran.

Table 4 shows the milk production of the last week of each period.

Table 4.—Milk Production by Weeks.

Cow.	Last week of Period I.	Last week of Period II.	Last week of Period III.	Last week of Period IV.
Dixie,	127.1	114.1	117.4	107.6
Lucretia,	136.2	126.5	109.1	96.5
Cibola,	162.7	155.0	152.7	148.3
Ruth,	182.9	172.4	161.5	151.7
Viola,	103.5	97.7	93.0	80.5
Total,	712.4	665.7	633.7	584.6
Average,	142.5	133.1	126.7	116.9
Drop,	.....	9.4	6.4	9.8
Tops,	173.6	175.8	152.1	148.2
Titia,	182.9	178.0	158.1	150.2
Mary,	121.4	116.1	94.4	84.3
Countess,	112.8	112.4	96.5	85.1
Laurel,	111.6	105.4	91.6	98.8
Total,	702.3	687.7	592.7	566.6
Average,	140.5	137.5	118.5	113.3
Drop,	.....	3.0	19.0	5.2

The average milk production of Lot I was 9.4 pounds less during the last week of period two than it was during the last week of period one. That is, the five cows fell off in milk production an average of 9.4 pounds during the three weeks they were on alfalfa meal. During this same period Lot II which had remained on wheat bran fell off an average of 3.0 pounds. The average milk production of Lot I during the last week of period three was 6.4 pounds less than during the last week of period two. That is, the decrease averaged three pounds less during this period than during the preceding one on alfalfa meal. The average production of Lot III during the last week of period two was nineteen pounds less than during the last week of period two. That is, this lot fell off on the average 19 pounds during the three weeks on alfalfa meal as against 3 pounds during the preceding three weeks, and 5.2 pounds during the following three weeks. During the last week of period four the average milk production of Lot I was 9.8 pounds less than it was during the last week of period three. This is a decrease of .4 of a pound more for the same lot than was made during the three weeks they were on alfalfa meal. During the last week of period four the average milk production of Lot II was 5.2 pounds less than during the last week of period three. Taking the average of the two periods during which Lot I was on wheat bran we find decrease to be 8.1 pounds, against 9.4 pounds on alfalfa meal.

In like manner we find the average decrease of Lot II on wheat bran to be 4.1 pounds, against 19 pounds on alfalfa meal.

Table 5 shows the production of butter fat during the different periods.

Table 5.—Butter Fat Production.

Cow.	Period I.		Period II.		Period III.		Period IV.	
	Per cent.	Pounds.	Per cent.	Pounds.	Per cent.	Pounds.	Per cent.	Pounds.
Dixie,	5.30	20.20	5.52	17.92	5.63	19.95	5.52	18.52
Lucretia,	4.70	19.78	5.02	19.48	5.40	19.09	5.33	16.75
Cibola,	4.86	23.84	5.04	23.67	5.17	24.02	4.99	22.70
Ruth,	4.05	22.40	4.11	21.61	4.37	21.80	4.32	20.30
Viola,	5.33	16.59	5.39	15.50	5.57	16.39	5.67	14.27
Total,	.....	102.81	.....	98.18	.....	101.31	.....	92.54
Average,	4.77	20.56	4.93	19.64	5.17	20.26	5.01	18.51
Tops,	4.87	25.46	5.11	26.94	5.10	23.89	5.08	23.05
Titia,	4.00	21.81	4.20	22.38	4.25	21.02	4.40	20.34
Mary,	5.37	19.55	5.53	20.21	5.65	16.99	5.56	15.22
Countess,	5.29	17.93	5.50	18.42	5.67	17.26	5.43	15.09
Laurel,	6.15	21.46	6.45	21.48	6.40	18.83	6.28	18.40
Total,	.....	106.21	.....	109.43	.....	97.99	.....	92.10
Average,	5.01	21.24	5.17	21.89	5.26	19.60	5.23	18.42

From this table it is seen that during Periods I, II and III there seemed to be a general increase in the percentage of butter fat regardless of the feed fed. This may be due in part to the advance of the period of lactation but the falling off in butter fat content during Period IV could not be accounted for in this way. The total amount of butter fat produced by Lot I was less during the period on alfalfa meal than during either the preceding or following periods. The total amount produced by Lot II was less when on alfalfa meal than during the preceding period but greater than during the following period. The milk of all the cows in Lot I increased in butter fat content when passing from bran to alfalfa meal but they also increased when passing from alfalfa meal back to bran. The milk of three of the cows in Lot II increased in fat content in passing from bran to alfalfa meal and that of two of them fell off. One increased in passing from alfalfa meal to bran while four of them decreased. There is not enough regularity or uniformity in the variation of butter fat content to warrant attributing it to the feed in any case.

Table 6 shows the production of solids-not-fat by the individual cows for the different periods.

Table 6.—Solids-not-Fat.

Cow.	Period I. Lbs.	Period II. Lbs.	Period III. Lbs.	Period IV. Lbs.
Dixie,	56.92	49.38	54.06	50.20
Lucretia,	57.78	55.44	51.52	45.52
Cibola,	69.44	68.61	66.94	65.55
Ruth,	73.90	70.30	68.38	65.34
Viola,	45.38	43.85	44.08	37.26
Total,	302.42	287.58	284.98	263.87
Average,	60.68	57.52	57.00	52.77
Tops,	75.03	77.54	68.90	65.83
Titia,	72.97	72.60	66.69	64.10
Mary,	55.12	56.19	46.44	41.74
Countess,	50.08	49.37	46.37	41.52
Laurel,	55.71	54.67	46.34	46.77
Total,	308.91	310.37	275.74	259.96
Average,	61.78	62.07	55.15	51.99

This table corresponds closely with Table 5 and shows no conclusive results.

METHODS OF STEER FEEDING.

BY THOS. I. MAIRS.

SUMMARY.

1. The general results of this test are similar to those of former trials mentioned at the beginning of this article.

2. The two lots of steers ate practically the same amount of feed and made practically the same gains.

3. The temperature of surroundings seems to have very little effect upon the rate of gain.

4. The steers in the barn seemed to gain more uniformly than those outside.

5. Stormy weather with much rain and snow affected adversely the steers in the open shed, and those in the barn to a less extent.

During the winter of 1905 and 1906, the work on steer feeding which had been in progress during the three preceding winters was continued. The results of the trial of 1902 and 1903 have been reported in Bulletin 64 of this Station; those of 1903 and 1904 in Bul-

letin 68; those of 1904 and 1905 in the annual report for those years. As stated in former bulletins, the object of this experiment was to test the relative economy of feeding steers out of doors in an open shed and feeding them in warm basement stables as is the common practice throughout this State. The chief points considered were as follows:

1. Gain in live weight.
2. Health and vigor of the animal as indicated by appetite and general appearance.
3. Amount of feed consumed per pound of gain.
4. Relation of gain to temperature and weather conditions.

A certain lack of uniformity in the results of former trials, particularly in the relation of gains to temperature and weather conditions, seemed to warrant a continuation of this work for another year.

Plan of the Experiment.

As in previous tests, twenty-four steers were divided into two lots of twelve each as nearly equal as possible on the basis of quality and condition, according to the judgment of experienced feeders. These two lots were also made practically equal in live weight. One lot was fed in the basement of the College barn; the other in an open shed which was described in Bulletin 64.

FEEDING AND MANAGEMENT.

The roughage consisted of shredded corn stover fed in the morning and mixed clover and timothy hay fed in the evening. The hay fed up to February 20 was second crop, that fed from February 20 to close of experiment was first crop. The grain ration consisted of corn and cob meal and cottonseed meal. It was fed somewhat differently from former years in that the corn and cob meal was not mixed with the cottonseed meal before feeding. The corn and cob meal was placed in the manger and one pound of cottonseed meal per steer spread over it. The reason for feeding in this manner was to compare Lot I, which was fed in the barn, with another lot, which was being fed broken ear corn in the place of corn and cob meal, as described in subsequent pages. The grain was fed in equal portions twice daily. The animals were required to eat all the hay and grain fed them and as much of the corn stover as was advisable. An effort was made to have them eat practically equal portions of corn stover and clover hay but this was found not to be practicable.

Twenty-one of these steers were bought in Pittsburg and shipped to the College about November 1, 1905. The other three were bought from a local dealer a few days later. They were all fed together up to within a few days of the opening of the experiment. Beginning November 28, the steers were weighed three days in succession and the average taken as the initial weight. After that they were weighed on three consecutive days at intervals of two weeks until the close of the experiment. Lot I had water constantly before them during the entire experiment. Lot II had water before them during the day time but to prevent freezing their trough was usually drained at night.

Table I gives the weights of the individual steers together with the total weight of each lot at the opening of the experiment on

November 29 and at two weeks intervals until the close, April 18, 1906.

Table I.—Weights of Individual Steers.

No. of Steer.	Nov. 29. Lbs.	Dec. 13. Lbs.	Dec. 27. Lbs.	Jan. 10. Lbs.	Jan. 24. Lbs.	Feb. 7. Lbs.	Feb. 21. Lbs.	Mar. 7. Lbs.	Mar. 21. Lbs.	Apr. 4. Lbs.	Apr. 18. Lbs.
Lot I—Barn.											
1, ...	1,087	1,112	1,162	1,209	1,251	1,261	1,279	1,309	1,322	1,353	1,388
2, ...	1,190	1,222	1,269	1,278	1,301	1,324	1,347	1,378	1,386	1,412	1,437
3, ...	1,093	1,100	1,129	1,144	1,182	1,223	1,255	1,281	1,309	1,347	1,375
4, ...	1,140	1,182	1,219	1,243	1,280	1,314	1,337	1,363	1,389	1,419	1,447
5, ...	1,077	1,095	1,145	1,175	1,201	1,238	1,247	1,288	1,294	1,316	1,328
6, ...	1,027	1,053	1,103	1,151	1,183	1,231	1,271	1,303	1,340	1,365	1,393
7, ...	1,355	1,380	1,420	1,449	1,479	1,514	1,535	1,575	1,603	1,631	1,643
8, ...	1,258	1,275	1,304	1,323	1,351	1,395	1,402	1,422	1,433	1,467	1,489
9, ...	998	1,012	1,059	1,080	1,103	1,143	1,166	1,203	1,204	1,239	1,252
10, ...	938	953	983	998	1,036	1,086	1,093	1,135	1,153	1,171	1,185
11, ...	1,193	1,200	1,231	1,247	1,257	1,292	1,300	1,327	1,346	1,372	1,347
25, ...	1,275	1,307	1,333	1,352	1,327	1,360	1,383	1,415	1,432	1,449	1,432
Total, ...	13,631	13,891	14,357	14,649	14,951	15.381	15,615	15,999	16,211	16,541	16,759
Lot II—Shed.											
36, ...	1,092	1,093	1,142	1,164	1,181	1,219	1,248	1,266	1,270	1,266	1,261
12, ...	1,120	1,138	1,181	1,191	1,225	1,266	1,275	1,327	1,326	1,348	1,378
13, ...	1,143	1,158	1,192	1,232	1,247	1,287	1,314	1,361	1,373	1,390	1,430
14, ...	1,230	1,297	1,353	1,403	1,450	1,499	1,549	1,588	1,602	1,627	1,678
15, ...	1,092	1,088	1,128	1,140	1,157	1,189	1,193	1,223	1,228	1,250	1,261
16, ...	1,245	1,255	1,298	1,336	1,363	1,398	1,431	1,455	1,477	1,496	1,528
17, ...	1,347	1,342	1,379	1,408	1,442	1,480	1,511	1,549	1,560	1,590	1,615
18, ...	1,053	1,060	1,078	1,103	1,132	1,176	1,201	1,226	1,221	1,248	1,290
19, ...	1,062	1,057	1,102	1,127	1,151	1,208	1,238	1,282	1,234	1,284	1,237
20, ...	1,168	1,175	1,182	1,224	1,253	1,294	1,316	1,351	1,359	1,400	1,429
21, ...	1,120	1,168	1,222	1,248	1,283	1,322	1,354	1,404	1,408	1,435	1,464
22, ...	1,098	1,095	1,154	1,175	1,206	1,258	1,294	1,335	1,332	1,357	1,405
Total, ...	13,820	13,926	14,411	14,751	15,090	15,596	15,924	16,367	16,390	16,691	17,066

As will be seen from this table, the total weight of Lot II at the beginning of the experiment was 189 pounds more than that of Lot I. At no time during the experiment was Lot I heavier than Lot II. At the close of the experiment Lot II was 307 pounds heavier than Lot I.

Table II gives the gain of individual steers for each two weeks during the test together with the total gain of each lot and the average gain per steer.

Table II.—Gain of Individual Steers.

Number of Steer.	1st period. Lbs.	2d period. Lbs.	3d period. Lbs.	4th period. Lbs.	5th period. Lbs.	6th period. Lbs.	7th period. Lbs.	8th period. Lbs.	9th period. Lbs.	10th period. Lbs.	Total gain. Lbs.
Lot I—Barn.											
1,	25	50	47	42	10	18	30	13	31	35	301
2,	32	47	9	23	23	23	31	8	26	25	247
3,	7	29	15	38	41	32	26	28	38	28	282
4,	42	37	24	37	34	23	26	26	30	28	307
5,	18	50	30	26	37	9	41	6	22	12	251
6,	26	50	48	32	48	40	32	37	25	28	366
7,	25	40	29	30	35	21	40	28	28	12	288
8,	17	29	19	28	44	7	20	11	34	22	231
9,	14	47	21	23	40	23	37	1	35	13	254
10,	15	30	15	38	50	7	42	18	18	17	250
11,	7	31	16	10	35	8	27	19	26	15	194
25,	32	26	19	—25	33	23	32	17	17	—17	157
Total,	260	466	292	302	430	234	384	212	330	218	3,128
Average,	22	39	24	25	36	20	32	18	27	18	261
Lot II—Shed.											
36,	1	49	22	17	38	29	18	4	—4	—5	169
12,	18	43	10	34	41	9	52	—1	22	30	258
13,	15	34	40	15	40	27	47	12	17	40	287
14,	17	56	59	47	49	50	39	14	25	51	398
15,	—4	40	12	17	32	4	30	5	22	11	169
16,	10	43	38	27	35	33	24	22	18	32	283
17,	—5	37	29	34	38	31	38	11	30	25	268
18,	7	18	25	29	44	25	25	—5	27	42	237
19,	—5	45	25	24	57	30	44	—48	50	43	265
20,	7	7	42	29	41	22	35	8	41	29	261
21,	48	54	26	35	39	32	50	4	27	29	344
22,	—3	59	21	31	52	36	41	—3	25	48	307
Total,	106	485	340	339	506	328	443	23	301	375	3,246
Average,	9	40	28	28	42	27	37	2	25	31	271

From this table it is seen that during seven of the ten periods the steers in the shed made better gains than those in the barn. One of the periods during which the steers in the barn made better gains than those outside was the initial period, which may possibly be accounted for in part by the steers not being accustomed to their surroundings. During one period in March the steers in the shed were practically at a stand still. This was during the coldest portion of the season when snow was falling practically every day. During this period one of the steers (No. 19) met with an accident which doubtless caused the loss of forty-eight pounds recorded against him. During the entire one hundred and forty days, Lot I gained 3,128 pounds or an average of 261 pounds per head, while Lot II gained a total of 324 pounds or an average of 271 pounds per head. If we omit the first period, Lot I made a total gain during the 126 days of 2,868 pounds or an average of 239 pounds per head, while Lot II made a total gain of 3,140 or an average of 262 pounds per head. The gains made by Lot I seem to be more uniform than those made by Lot II, the range in Lot I being from 157 pounds to 366 pounds, that in Lot II from 169 pounds to 398 pounds. Three steers in Lot II and two steers in Lot I gained over 300 pounds and two in each lot gained less than 200 pounds each. One steer in Lot II gained practically 400 pounds.

Table III shows the amount of feed consumed by the two lots for the various periods.

Table III.—Feed Consumed.

Date.	Stover. Offered. Lbs.	Stover. Refused. Lbs.	Stover. Eaten. Lbs.	Hay. Lbs.	Corn and cob meal. Lbs.	Cottonseed meal. Lbs.
Lot I—Barn.						
Nov. 29-Dec. 12,	1,056.5	1,260.0	299.5	960.5	2,045.0	216
Dec. 13-Dec. 26,	1,058.5	1,151.0	296.5	854.5	2,774.5	252
Dec. 27-Jan. 9,	1,028.5	1,057.5	329.5	728.0	3,198.5	336
Jan. 10-Jan. 23,	1,005.5	1,067.5	417.5	650.0	3,167.5	336
Jan. 24-Feb. 6,	840.5	853.5	262.5	591.0	3,370.0	336
Feb. 7-Feb. 20,	790.5	836.5	226.5	610.0	3,380.5	336
Feb. 21-Mar. 6,	711.5	775.5	255.5	520.0	3,305.5	336
Mar. 7-Mar. 20,	589.5	750.0	218.0	532.0	3,299.5	336
Mar. 21-Apr. 3,	589.0	794.5	277.0	517.5	3,269.0	336
Apr. 4-Apr. 17,	633.0	858.0	266.5	591.5	3,295.0	336
Total,	8,303.0	9,404.0	2,849.0	6,555.0	31,105.0	3,156
Lot II—Shed.						
Nov. 28-Dec. 16,	1,072.0	1,253.5	136.5	1,117.0	2,014.5	216
Dec. 13-Dec. 26,	1,064.5	1,133.5	154.0	979.5	2,788.0	252
Dec. 27-Jan. 9,	1,032.5	1,074.0	180.0	894.0	3,148.0	336
Jan. 10-Jan. 23,	989.5	1,092.0	206.0	886.0	3,180.0	336
Jan. 24-Feb. 6,	999.5	1,023.5	222.0	801.5	3,210.0	336
Feb. 7-Feb. 20,	971.0	1,032.5	218.5	814.0	3,337.0	336
Feb. 21-Mar. 6,	821.5	741.5	197.0	544.5	3,048.5	336
Mar. 7-Mar. 20,	685.5	838.5	185.5	653.0	3,370.5	336
Mar. 21-Apr. 3,	759.5	772.5	194.5	578.0	3,384.0	336
Apr. 4-Apr. 17,	777.0	809.0	276.0	533.0	3,385.0	336
Total,	9,172.5	9,770.5	1,970.0	7,800.5	30,865.5	3,156

It appears from this table that Lot I ate more hay and stover and made slightly less gain than Lot II. Lot II ate the stover considerably cleaner than Lot I indicating that their appetites were better. It was almost impossible to get Lot I to eat the stover as closely as Lot II without cutting down their hay ration more than was thought desirable. The stover refused by Lot II consisted of only the coarser portions which it was not thought advisable to force them to eat.

Table IV shows the amount of feed eaten per pound of gain. It also shows the cost of feed per pound of gain assuming the hay to be worth $8 per ton, the corn stover $4 per ton, corn and cob meal $18 per ton and cottonseed meal $28 per ton.

Table IV.—Amount and Cost of Feed per Pound of Gain.

	Amount—Pounds. Lot I.	Amount—Pounds. Lot II.	Cost—Cents. Lot I.	Cost—Cents. Lot II.
Hay,	2.65	2.83	1.060	1.132
Stover,	3.01	3.01	.602	.602
Corn and cob meal,	9.94	9.51	8.946	8.559
Cottonseed meal,	1.01	.97	1.414	1.358
Total,			12.022	11.651
Difference,				.371

From this table it is seen that the two lots ate practically the same amount of feed per pound of gain. While Lot II made gains at slightly less cost than Lot I, the difference is not great enough to warrant any decided statements being made in favor of either method.

Table V shows the total gain of each lot by periods, together with the maximum, minimum and mean temperature of each period as recorded at the U. S. Weather Bureau Station about a half mile distant from the cattle barn.

Table V.—Temperature and Gains.

	Gains.		Temperature.		
	Lot. I.	Lot II.	Maximum.	Minimum.	Mean.
November 29-December 12,	260	106	52	9	33
December 13-December 26,	466	485	44	12	31
December 27-January 9,	292	340	49	6	31
January 10-January 23,	302	339	66	12	35
January 24-February 6,	430	506	55	—8	27
February 7-February 20,	234	328	55	—1	24
February 21-March 6,	384	443	59	8	33
March 7-March 20,	212	23	42	11	29
March 21-April 3,	330	301	60	1	32
April 4-April 17,	218	375	67	32	48

As in former years, there seems to be no definite relation between temperature and gains. The range between the maximum and minimum temperature varied from 31 degrees during the eighth period to 63 degrees during the fifth period. Strange as it may seem the steers in the open shed made their best gains during the period of widest range and their poorest gains during the period of narrowest range. The steers in the barn also made their poorest gains during the period of narrowest range but made their best gains during the period of second narrowest range. The second best gains made by the steers in the barn were made during the period of widest range. That is, during the period of widest range, Lot II made their best gains and Lot I made their second best gains. During the period of narrowest range both lots made their poorest gains. Lot I made their best gains during the period of the second narrowest range. During the period of narrowest range, from March 7 to March 20, the weather was very stormy, snow falling every day. Up to this time the winter had been comparatively dry. As in former years the steers seemed to be more sensitive to humidity than to temperature. A cold dry period conduces to large gains both outside the barn and within. A damp period even though warm, almost always results in lessened gains.

METHODS OF STEER FEEDING.

CORN AND COB MEAL VS. BROKEN EAR CORN.

BY THOS. I. MAIRS.

SUMMARY.

1. The two lots of steers ate practically equal amounts of corn and cob meal and broken corn.

2. The steers on corn and cob meal gained on the average 24 pounds per head more than those on broken ear corn during 126 days.

3. The cost of preparing the corn and cob meal was about $3 per ton more than that of breaking corn.

4. The extra cost was not offset by the increased gains.

In addition to the two lots of steers described in the preceding article, a third lot of 12 steers was fed in a similar manner to Lot I with the exception that they received broken ear corn instead of corn and cob meal. These steers were selected from a car load bought of a local dealer about November 1. In selecting the steers for this lot, an attempt was made to have them as nearly like Lot I in condition, quality and live weight as could be determined, but they were hardly in as good condition to begin with as the ones already described and were possibly of not quite so good quality.

This lot was fed in a pen of almost exactly the same size as that in which Lot I already described was fed and had water constantly before them. The aim was to have all the conditions for the two lots identical, with the exception that one lot was to receive corn and cob meal and the other broken ear corn.

Table I.—Weights of Individual Steers.

Number of Steer.	Lbs. Nov. 29.	Lbs. Dec. 13.	Lbs. Dec. 27.	Lbs. Jan. 10.	Lbs. Jan. 24.	Lbs. Feb. 7.	Lbs. Feb. 21.	Lbs. Mar. 7.	Lbs. Mar. 21.	Lbs. Apr. 4.
Lot III.										
32,	1,138	1,140	1,199	1,213	1,211	1,255	1,286	1,290	1,301	1,319
33,	1,073	1,090	1,094	1,122	1,168	1,204	1,233	1,249	1,255	1,281
34,	1,137	1,167	1,283	1,243	1,268	1,303	1,330	1,355	1,361	1,373
35,	1,090	1,117	1,146	1,180	1,192	1,235	1,262	1,292	1,291	1,309
23,	1,027	1,047	1,127	1,145	1,132	1,179	1,202	1,217	1,215	1,233
26,	1,260	1,260	1,301	1,327	1,362	1,387	1,438	1,464	1,478	1,512
27,	1,165	1,195	1,210	1,257	1,302	1,321	1,370	1,395	1,387	1,385
28,	1,128	1,175	1,212	1,251	1,285	1,322	1,345	1,394	1,399	1,419
29,	1,210	1,217	1,250	1,272	1,286	1,314	1,347	1,375	1,377	1,408
30,	1,275	1,283	1,314	1,343	1,378	1,397	1,422	1,447	1,465	1,483
31,	1,210	1,255	1,286	1,295	1,332	1,390	1,404	1,378	1,398	1,401
Total,	12,713	12,946	13,377	13,648	13,916	14,307	14,639	14,856	14,927	15,123
Average,	1,156	1,177	1,216	1,241	1,265	1,301	1,331	1,351	1,357	1,375
Lot I.										
Total,	13,631	13,891	14,357	14,649	14,951	15,381	15,615	15,999	16,211	16,541
Average,	1,136	1,158	1,188	1,221	1,246	1,282	1,301	1,333	1,350	1,378

Table I shows the weight of the individual steers from the beginning of the experiment, November 29, by intervals of two weeks, to its close, April 4. The weights given are in each case averages of weighings on three consecutive days. One steer was accidentally crippled and was removed from the lot early in the experiment. Although this steer was fed in the lot to January 24, its weight will not be considered.

This table also shows the total and average weight for Lot I for the different periods. The weights of the individual steers of this lot are given in a previous table.

Table II.—Gains of Individual Steers.

Number of Steer.	1st period. Lbs.	2d period. Lbs.	3d period. Lbs.	4th period. Lbs.	5th period. Lbs.	6th period. Lbs.	7th period. Lbs.	8th period. Lbs.	9th period. Lbs.	Total. Lbs.
Lot III.										
32,	2	59	14	—2	44	31	4	11	18	181
33,	17	4	28	46	36	29	16	6	26	208
34,	30	71	5	25	35	27	25	6	12	236
35,	27	29	34	12	43	27	30	—1	18	219
23,	20	80	18	—13	47	23	15	—2	18	206
26,	0	41	26	35	25	51	26	14	34	252
27,	30	15	47	35	19	49	225	—8	—2	220
28,	47	37	39	34	37	23	49	5	20	291
29,	7	33	22	14	28	33	28	2	31	198
30,	8	31	29	35	19	25	25	18	18	208
31,	45	31	9	37	58	14	—26	20	3	191
Total,	233	431	271	258	391	332	217	71	196	2,410
Average,	21	39	25	23	36	30	20	6	18	219
Lot I.										
Total,	260	466	292	302	430	234	384	212	330	2,910
Average,	22	39	24	25	36	20	32	18	27	243

Table II shows the gains of the individual steers in Lot III for the different periods. It also shows the total gain of the individual steers for the entire experiment and the total average gain of Lot I for the same time. From this table, it is seen that in seven of the nine periods Lot I made a greater average gain than Lot III. In two periods the gains made by the two lots were the same. It seems that the gains made by Lot I were more uniform than those made by Lot III. The average gain made by Lot I for the entire period was almost 24 pounds more than that made by Lot III.

Table III.—Feed Consumed.

Period.	Stover. Offered. Lbs.	Stover. Refused. Lbs.	Stover. Eaten. Lbs.	Hay. Lbs.	Corn. Lbs.	Cottonseed meal. Lbs.
Lot III.						
Nov. 29-Dec. 12,	1,064.7	870.4	287.8	582.6	2,425.4	198
Dec. 13-Dec. 26,	980.4	788.0	209.9	578.1	2,615.7	231
Dec. 27-Jan. 9,	891.5	689.3	199.4	489.9	2,780.7	308
Jan. 10-Jan. 23,	761.7	809.0	237.4	561.6	2,671.2	308
Jan. 24-Feb. 6,	769.0	722.3	200.3	522.0	2,805.9	308
Feb. 7-Feb. 20,	801.0	804.5	276.5	528.0	2,785.5	308
Feb. 21-Mar. 6,	763.0	846.0	352.5	493.5	3,035.0	308
Mar. 7-Mar. 20,	603.5	747.5	260.0	487.5	3,050.0	308
Mar. 21-Apr. 3,	557.0	789.5	293.0	496.5	3,106.5	308
Total,	7,191.8	7,066.5	2,316.8	4,749.7	25,275.9	2,585
Average per steer,	653.8	624.4	210.6	431.8	2,297.8	235
Lot I.						
Total,	7,670.0	8,546.0	2,583.0	5,964.0	27,480.5	2,820
Average per steer,	639.2	712.2	215.2	497.0	2,290.0	2,820

Table III shows the amount of feed eaten by Lot II for the different periods, the total amount eaten during the entire period and the total amount eaten by Lot I during the same time. Since Lot III contained only 11 steers from January 24, the feeding is computed on the basis of this number for the entire period. From this table it is seen that the two lots ate practically equal amounts of feed, Lot I eating a little more hay and grain and Lot VII a little more stover but the difference is too slight to be taken into account.

The question seems to resolve itself into the relative cost of the two methods of preparing corn. The following statement shows approximately the cost of the corn per steer for the 126 days of the experiment.

Lot III.

To 2,297.8 pounds of ear corn at 50 cents per bushel,	$16.413
To breaking 2,297.8 pounds of corn at 1 cent per bushel,	328
	$16.741

Lot I.

To 2,290.0 pounds of ear corn at 50 cents per bushel,	$16.357
To grinding 2,290 pounds of corn and cob meal at 10 cents,	2.290
To man and team half day taking corn to mill,	1.500
	$20.147
	16.741
Difference in favor of broken corn,	**$3.406**

The cost of broken corn is based upon the average time required per day to break the corn for the 12 steers. The cost of grinding is based upon the usual rate charged by millers throughout Pennsylvania when cash is paid. From this statement it is seen that the feed for one steer cost $3.406 more when corn and cob meal was fed than when broken corn was fed. Lot I, on the corn and cob meal, gained 24 pounds more than Lot III, on the broken corn. It is obvious that this additional gain is far from sufficient to pay the extra cost of grinding.

When hogs follow the steers the difference is still greater. According to results obtained at the Illinois Experiment Station 100 pounds of corn ears fed to steers will produce 1.68 pounds of pork. One hundred pounds of corn and cob meal fed to steers will produce .46 pounds of pork. On this basis each steer on broken corn would produce about 28 pounds more pork than on corn and cob meal. Assuming this pork to be worth 5 cents per pound would make an additional difference of $1.40 in favor of the broken corn or a total difference of $4.806 in favor of this lot. This difference may be considered quite important in view of the narrow margin on which steers are fattened.

DIVISION OF ANIMAL NUTRITION.

HENRY PRENTISS ARMSBY, Ph. D., LL. D., Director.

J. AUGUST FRIES, M. S., ... First Assistant.
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ARTHUR B. ROSENKRANZ, ...

This Division, as heretofore, has been under the immediate charge of the Director of the Station.

Investigations in animal nutrition in co-operation with the Bureau of Animal Industry of the U. S. Department of Agriculture were undertaken in 1898, when the construction of a respiration calorimeter for domestic animals was begun. The completion of this large and complicated apparatus occupied fully three years, the first experiment with animals having been conducted in the winter of 1901-2 and work having been continued up to the present time.

The investigations constitute a careful, scientific study of the fundamental principles of animal nutrition. Starting with the food as a source of energy to the animal machine, they follow this energy through to its ultimate effect, determining how much escapes in the undigested residues of the food, how much is expended in the digestion and assimilation of the food, and what surplus remains to sustain the life of the animal or enable it to produce meat, milk or work. The investigations are complicated, requiring the services of not less than seven men for the actual conduct of an experiment, and involve in addition a large amount of laboratory work and extensive computations. Hence it is not strange that the results seem slow in accumulating. The results thus far published include experiments upon timothy hay, red clover hay and corn meal as to their relative values both for maintenance and for productive purposes. An outline of the results obtained has been published in Bulletin No. 74 of the Bureau of Animal Industry and in Bulletin No. 71 of the Pennsylvania Station.

More important than the mere numerical results, however, has been the aid which the experiments have afforded in clearing up some fundamental points regarding the energy relations between the food and the animal. At the time when these investigations were begun, the prevailing ideas were based largely on Rubner's earlier investigations which were popularized in the United States by the writings of Atwater. It was then supposed that the so-called

*To October 1, 1905.
†To January 1, 1906.
‡October 1, 1905, to May 10, 1906.
§From January 1, 1906.

"fuel values" of feeding stuffs, that is the amount of heat which they were capable of giving off in the body, was a measure of their nutritive value, and Rubner's factors for the fuel values of human food were used quite generally to compute the fuel values of the digestible nutrients of stock foods, a proceeding natural enough at that time, but which unfortunately seems to have proved less susceptible to change than the ideas on which it was based.

The investigations of Kellner in Germany and those at the Pennsylvania Experiment Station have amply demonstrated that this conception was erroneous, and that the real values of stock feeds are much less than their fuel values. That this should be true in the fattening or milk producing animal is not so surprising, but that it should prove to be the case on a simple maintenance ration compels a material modification of our general conceptions and is of fundamental importance to the theory of the subject. The Pennsylvania experiments have shown in the first place that the real fuel values of stock feeds are less than the computed ones, and that, moreover, but a fraction of the real fuel value of stock feeds is utilized for any purpose in the body. In the three cases thus far investigated, the real values for maintenance were found to range from 56 per cent. of the fuel values computed from the digestible nutrients in the case of timothy hay to 67 per cent. in the case of corn meal. On the basis of the digestible nutrients, 174 pounds of timothy hay appeared to be equal to 100 of corn meal for maintenance, while in reality 211 pounds were required. For fattening the discrepancy was still greater, 273 pounds of timothy hay being required to equal 100 of corn meal.

A series of experiments designed to study what effect the age and breed of the animal has upon the percentage of food energy utilized has now been in progress for two years, but the results are not yet sufficiently complete for publication. Later it is hoped that more extended data regarding the actual values of other feeding stuffs may be secured.

In the course of these investigations, a considerable amount of valuable experience has been gained regarding technical details of the methods employed. In the present report, a paper by Mr. Fries describes very fully the sources of error in the method commonly used for the determination of heats of combustion of feeding stuffs and excreta. It is hoped to follow this paper at intervals by others relating to the various methods employed in nutrition investigations.

INVESTIGATIONS IN THE USE OF THE BOMB CALORIMETER.

By J. AUGUST FRIES.

INTRODUCTORY.

In scientific investigations, as well as in technical work, it is often of very great importance to know the exact heat of combustion, or, in other words, the energy value of a substance. To determine the heats of combustion of organic compounds it is necessary to completely oxidize them to their most simple or stable decomposition products and measure the heat evolved. Several methods have been used for such determinations, but the latest and best for the greater number of compounds is undoubtedly the Berthelot, or bomb-calorimeter method, where the substance to be analyzed is burned in oxygen gas under high pressure. Detailed descriptions of this apparatus and directions for its use are found in various scientific works, hence no full description need be given here.

THE APPARATUS USED.

The apparatus used for the work described in this paper was the Atwater-Hempel bomb calorimeter, which is a modification of the Berthelot apparatus.* The main features only of its construction and manipulation will be referred to briefly at this time.

The apparatus consists of the bomb proper, which is a strong steel cup lined on the inside with platinum, and of a platinum-lined top which rests on a lead washer and is firmly held in place by a threaded collar. A cylindrical vessel of Britannia metal is used for holding the water in which the bomb is immersed. The apparatus is provided with a stirring arrangement operated by means of an electric motor. Outside of this metal vessel are two concentric protecting cylinders made of indurated fiber, each provided with a cover. These fiber cylinders, with the dead air spaces between them, serve to insulate and protect the metal vessel and the water as far as possible from being affected by any change of outside or room temperature or circulation of air. A Beckmann mercury thermometer, which can be read to 0.001° C. with accuracy, is used for taking the temperature of the water.

*U. S. Dept. Agr., Office of Experiment Stations Bul. 21. Conn (Storrs) Sta. Rept. 1897, p. 199.

MANIPULATION OF THE APPARATUS.

The substance to be burned, if solid, is pressed into a tablet of convenient size, placed in a platinum capsule, which is supported on a platinum wire attached to the top or cover of the bomb, and adjusted so that the substance will come in contact with the fine iron fuse wire by means of which it is ignited. The bomb is then charged with oxygen gas to a pressure of at least 20 atmospheres. It is immersed in the weighed quantity of water, the electric connections are made, and the covers adjusted and clamped so that the stirrer will not rub. After placing the thermometer in position the stirrer is started and the temperature of the water taken. It is intended to have the water as much colder than the surrounding air before the combustion as it will be warmer after the combustion. As soon as a uniform rate of change in the water temperature has been established the substance is ignited. For this purpose an electric current strong enough to fuse instantly the fine iron wire is allowed to pass through, and by the burning of the fuse wire the substance in the capsule is also instantly ignited. The combustion is only of a few seconds duration, and the heat formed is quickly transmitted through the bomb to the surrounding water. Readings of the thermometer are taken every minute, and from the rise in temperature of the water the heat generated is calculated.

CALCULATION OF RESULTS.

In the calculation of the results it is necessary to apply several corrections. Not only the fixed weighed quantity of water but the whole system—bomb, stirrer, metal vessel, etc.—is heated up to the same degree, therefore the correct thermoequivalent of it must be determined and used. Thermometer readings must be corrected according to the individual thermometer used. Corrections are also made for the influence of the surrounding air temperature, the heat generated by the burning of the fuse wire, the formation of nitric acid in the bomb, and the lag of the thermometer.

The formula which has been used in working out the correction for the outside air influences is the Regnault-Pfaundler formula, given in Wiley's Principles and Practice of Agricultural Analysis, Volume III, page 572, and the following example will serve to illustrate the main points to be observed in connection with the determination and calculation of the heat of combustion.

Formula:

$$\frac{v-v^1}{t^1-t}\left(\sum_{1}^{n-1}\theta_r+\frac{\theta_n+\theta_1}{2}-n\theta\right)-(n-1)v=\Sigma\Delta t.$$

$\sum_{1}^{n-1}\theta_r$ = sum of θ readings minus 1 increased by an arbitrary factor $\frac{\theta_2-\theta_1}{9}$

v = average rate of radiation during preliminary period.
v^1 = average rate of radiation during end period.
θ = number of readings during combustion period.
t = average of preliminary thermometer readings.
t^1 = average of end period thermometer readings.

Example: Cellulose.
Cellulose, dried at 105° C. 1.0035 gram.
Iron fuse wire 0.0118 — 0.0018 = 0.0100 gram = 16 calories.
Oxygen pressure = 24 atmospheres.
Room temperature, 21° C.
Water temperature, 19° C. at beginning.
HNO_3 titrated = 13.5 c. c. NaOH sol. = 13.5 calories.
Cellulose ignited instantly.

Thermometer readings begin,	1.220,	1.220,	1.220,	1.221,	1.221,	1.221.
Corrected readings begin,	1.2265,	1.2265,	1.2265,	1.2275,	1.2275,	1.2275.
Combustion period,	1.221,	2.630,	2.933,	2.952,	2.952.	
Corrected readings,	1.2275,	2.6414,	2.9450,	2.9640,	2.9640.	
End period,	2.952,	2.949,	2.945,	2.941,	2.937.	
Corrected reading,	2.9640,	2.9610,	2.9570,	2.9530,	2.9490.	

$v = 0.0002.$
$t = 1.2270.$
$\theta = 5.$
$v^1 = -0.0038.$
$t^1 = 2.9565.$

$$\frac{0.0002-(-0.0038)}{2.9565-1.2270}\left(9.9350+2.0958-6.1350\right)-0.0008=+0.013°.$$

$$\Sigma\ \Delta\ t=+0.013°.$$

Last reading of combustion period,	+ 2.9640° C.
First reading of combustion period,	— 1.2275° C.
Correction for outside air,	+ 0.0130° C.
Correction for thermometer lag,	— 0.0006° C.
	1.7489° C.
Correction for excess oxygen,	+ 0.0003° C.
Correction for impurities in oxygen,	— 0.0151° C.
Corrected rise in temperature,	+ 1.7341° C.

Water value of bomb system with 20 atmospheres (2,439.2) × rise =	4229.82 calories.
Correction for fuse wire,	— 16.00 calories.
Correction for HNO_3,	— 13.50 calories.
	4229.32 calories.

4229.32 ÷ 1.0035 = 4185.7 calories per gram of cellulose.

Should for some reason the current of electricity remain on for a few seconds before the wire fuses correction should be made for the heat generated by the current.

IMPORTANCE OF THE APPARATUS IN CALORIMETRIC DETERMINATIONS.

Not only in physical and chemical laboratories do calorimetric determinations find application, but they have acquired special prominence in connection with physiological investigations and research work, and it is in this line of work that at the present time their application in the agricultural science has been found to be of so great importance. Thus, the very elaborate, time-consuming, and expensive nutrition investigation experiments with cattle by the use of the respiration calorimeter are so planned that the successful solving of the question of energy metabolism in the animal body rests almost entirely upon the bomb calorimeter—upon its efficiency in quickly and accurately determining the heats of combustion of feed and excretia. Being, then, a most important part of the whole plan, and since so much depends upon the work of this apparatus, one is not justified, because much work has been done with it in the past, in assuming that it is perfect in all respects, or that it is adapted alike to all kinds of organic substances. Instead, it should be severely tested from different points of view, and that was the object of this work.

EARLIER DETERMNATIONS OF HEATS OF COMBUSTION.

To begin with, it may be well to look a little into the work already done, and note the condition in which our knowledge of the heat values of organic substances is at the present time, and how well different investigators agree in their determinations. For this purpose, as well as to get a general idea of heat values, I have, without going back to the original source of the information, collected and tabulated a large number of results upon the heats of combustion of the more common organic substances as obtained by various investigators. The values are taken from text-books and scientific reference books, some of which are still in use in schools and elsewhere.

To make the tables as condensed as possible the works or books referred to are represented in one column, each book by a single number, and the investigators in another column by the first letters of their respective names.

TABLE I.—Heats of combustion of 1-gram substance, expessed in small calories.

Substances.	Formulas.	Calories.	References. a.	Investigators. a.
ELEMENTS, ETC.				
Hydrogen,	H_2	34,462.0	1,3	F. & S.
Hydrogen (8 investigators),	H_2	b34,154.3	10	F. & S.
Do.	H_2	c34,800.0	10	H.
Carbon,	C	7,770.1	10	F. & S.
Charcoal (wood),	C	8,080.0	1,3,10	F. & S.
Charcoal (sugar),	C	7,714.0	10	Gr.
Do.	C	8,039.8	10	F. & S.
Do.	C	7,965.0	10	Sch.
Diamond (to CO_2),	C	7,859.0	10	B. & P.
Diamond (to CO),	C	2,141.7	10	B.
Iron (to Fe_2O_3),	Fe	1,600.0	9	.....
Iron (to FeO),	Fe	1,352.6	10	F. & S.
Sulphur,	S_2	2,260.3	10	F. & S.
Do.	S_2	2,165.6	10	B.
Sulphur (soft),	S_2	2,220.5	10	F. & S.
Do.	S_2	2,162.5	3	F. & S.
CO to CO_2,	.....	2,436.0	3	F. & S.
Do.	.....	2,431.0	10	An.
Do.	.....	2,402.7	10	F. & S.
Do.	.....	2,438.6	10	B.
Do.	.....	2,441.7	10	Th.
Nitrogen to HNO_3 (sol.),	N_2	1,022.6	8	.....
NO to NO_2,	.....	652.3	10	Th.
PROTEIDS, ETC. (ALBUMINOIDS.)				
Gluten,	.....	5,990.3	2	B.
Do.	.....	6,141.0	2	D.
Elastin,	.....	5,961.3	1,2,10	St. & L.
Plant fibrin,	.....	5,832.3	2,10	B. & A.
Do.	.....	5,941.6	2,10	St. & L.
Do.	.....	6,231.0	1,2	D.
Serum albumin,	.....	5,917.8	1,2,8,10	St. & L.
Syntonin,	.....	5,907.8	2,1	St. & L.
Hemoglobin,	.....	5,910.0	2,10	B. & A.
Do.	.....	5,914.8	1,3	B. & A.
Do.	.....	5,885.1	1,2,3,10	St. & L.
Do.	.....	5,950.0	2	Ru.
Do.	.....	5,949.0	1,2,3,10	D.
Milk casein,	.....	5,626.4	2,10	B. & A.
Do.	.....	5,867.0	2,3,8,10	St. & L.
Do.	.....	5,629.2	1,3	B. & A.
Do.	.....	5,717.0	1,2,3,10	St.
Do.	.....	5,785.0	2	D.
Do.	.....	5,849.6	2,3,10	St. & L.
Do.	.....	5,858.0	1	St. & L.
Do.	.....	5,855.0	1	D.
Yolk of egg,	.....	8,112.4	2.3	B. & A.
Yolk of egg (fat free),	.....	5,840.9	3,10	St. & L.
Legumin,	.....	5,793.1	1,2,10	St. & L.

a Abbreviations:

Works referred to—

1. Bunge, Physiological Chemistry, fourth German edition, 1902.
2. Armsby, Principles of Animal Nutrition, 1904, and U. S. Department of Agriculture, Office of Experiment Stations, Bulletin 21.
3. Beilage, Chemiker Kalender, 1904.
4. Tollen, Handbuch I der Kohlehydrate, 1898.
5. W. Ostwald, Grundriss der Allgemeinen Chemie, 2te Auflage, 1890.
6. Tollen, Handbuch II der Kohlehydrate, 1895.
7. Jones, Elements of Physical Chemistry, 1903.
8. Wiley, Principles and Practice of Agricultural Analysis, Vol. III, 1897.
9. Journal American Chemical Society, Vol. XXV, 1903.
10. Landolt & Börnstein, Physikalisch-Chemische Tabellen, 1894.

Investigators—

A. André.
An. Andrews.
B. Berthelot.
Bu. Bunson.
D. Danilewsy.
Du. Dulong.
F. Favre.
Fo. Fogh.
Fr. Frankland.
Gi. Gibson.
Go. Gottlieb.
Gr. Grassi.
H. Hess.
He. Herzberg.
J. Jahn.
K. Kleber.
L. Langbein.
Lu. Luginni.
M. Matignon.
O. Ogier.
P. Petit.
Rch. Rechenberg.
Re. Recoura.
Ro. Rodolz.
Ru. Rubner.
S. Sibermann.
Sch. Schwackhöfer.
St. Stormann.
T. Tower.
Th. Thomsen.
V. Vieille.

b Lowest.
c Highest.

Substances.	Formulas.	Calories.	References. a.	Investigators. a.
Do.		5,573.0	2	D.
Vitellin,		5,780.6	2,10	B. & A.
Do.		5,745.1	1,2,3,10	St. & L.
Do.		5,784.1	3	St. & L.
Egg albumin,		5,687.4	1,2,10	B. & A.
Do.		5,735.2	1,2,3,8,10	St. & L.
Do.		5,579.0	1,2,3,10	St.
Do.		5,690.6	3	St.
Muscle (fat free and water),		5,728.4	2,10	B. & A.
Muscle (extracted),		5,720.5	2,8,10	St. & L.
Muscle (fat free),		5,662.6	2,10	St. & L.
Do.		5,324.0	2,10	St.
Muscle (fat free, ash free),		5,656.0	2,10	Ru.
Do.		5,640.9	2,10	St. & L.
Do.		5,345.0	10	Ru.
Albumin cryst,		5,672.0	1,2,10	St. & L.
Do.		5,598.0	1,2,10	St.
Blood fibrin,		5,529.1	2,10	B. & A.
Do.		5,637.1	2,3,10	St. & L.
Do.		5,511.0	1,2,3,10	St.
Do.		5,709.0	2	D.
Do.		5,772.0	1	D.
Do.		5,532.4	3	St.
Do.		5,567.3	3	St.
Albumin (Harnack's),		5,553.0	2	St. & L.
Wool,		5,564.2	2	B. & A.
Do.		5,510.2	2	St. & L.
Congluten,		5,479.0	2,10	St. & L.
Do.		5,362.0	2,10	St.
Fibrin of skin,		5,355.1	2,10	St. & L.
Peptone,		5,298.8	1,2,3,8,10	St. & L.
Do.		4,876.0	1	D.
Do.		4,914.0	1	D.
Do.		5,069.0	2	D.
Fish glue,		5,240.1	2,10	B. & A.
Do.		5,493.0	1,2	D.
Chondrin,		5,342.4	1,2,3,10	B. & A.
Do.		5,130.6	1,2,3,10	St. & L.
Do.		4,909.0	2	D.
Ossein,		5,410.4	1,2,10	B. & A.
Do.		5,039.9	1,2,10	St. & L.
Fibroin,		5,095.7	2,10	St. & L.
Do.		4,979.6	2,10	St. & L.
Chitin,		4,655.0	2,10	St. & L.
Do.		4,650.3	2,10	B. & A.
Tunicin,		4,146.8	2,10	B. & A.
Paraglobulin,		5,637.0	1,2,10	St.
Legumin,		5,793.0	1,10	St. & L.
Proteids (mean),		5,730.8	8	
AMIDES, ETC.				
Urea,	CON_2H_4	2,530.1	2,10	B. & P.
Do.	CON_2H_4	2,541.9	1,2,10	St. & L.
Do.	CON_2H_4	2,465.0	1,2,5,10	St.
Do.	CON_2H_4	2,537.0	1,2	D.
Do.	CON_2H_4	2,523.0	2,10	R.
Do.	CON_2H_4	2,121.0	1	F.
Glycocoll,	$C_2H_5NO_2$	3,136.6	2,9,10	B. & A.
Do.	$C_2H_5NO_2$	3,129.1	2,9,10	St. & L.
Do.	$C_2H_5NO_2$	3,050.0	1	St.
Do.	$C_2H_5NO_2$	3,053.0	2,10	St.
Alanin,	$C_3H_7NO_2$	4,370.7	2,10	B. & A.
Do.	$C_3H_7NO_2$	4,355.5	2,10	St. & L.
Leucin,	$C_6H_{13}NO_2$	6,536.5	1,2,10	B. & A.
Do.	$C_6H_{13}NO_2$	6,525.1	1,2,10	St. & L.
Sarkosin,	$C_3H_7NO_2$	4,505.9	1,2,10	St. & L.
Hippuric acid,	$C_9H_9NO_3$	5,659.3	1,2,9,10	B. & A.
Do.	$C_9H_9NO_3$	5,668.2	1,2,9,10	St. & L.
Do.	$C_9H_9NO_3$	5,642.0	2,5,10	St.
Aspartic acid,	$C_4H_7NO_4$	2,911.1	2,10	B. & A.
Do.	$C_4H_7NO_4$	3,423.0	1	St.
Do.	$C_4H_7NO_4$	2,899.0	2,10	St. & L.
Tyrosin,	$C_9H_{11}NO_3$	5,915.9	1,2,10	B. & A.
Asparagin,	$C_4H_8N_2O_3$	3,396.8	2,10	B. & A.
Do.	$C_4H_8N_2O_3$	3,514.0	2,10	St. & L.
Do.	$C_4H_8N_2O_3$	3,428.0	2,10	St.
Creatin cryst.	$C_4H_9N_3O_2H_2O$	3,714.1	1,2,10	St. & L.
Creatin, anhydrous,	$C_4H_9N_3O_2$	4,275.4	1,2,10	St. & L.
Do.		(3,206.0)	2	D.
Uric acid,	$C_5H_4N_4O_3$	2,754.0	2,10	B. & M.
Do.	$C_5H_4N_4O_3$	2,749.3	1,2,10	St. & L.
Do.	$C_5H_4N_4O_3$	2,621.0	1,2,5,10	St.
Do.	$C_5H_4N_4O_3$	2,645.0	1	Fr.
Guanin,	$C_5H_5N_5O$	3,891.7	1,2	St. & L.
Guanidin,	CH_5N_3	4,197.0	10	M.
Caffein,	$C_8H_{10}N_4O_2$	5,231.4	1,2,10	St. & L.

Substances.	Formulas.	Calories.	References. a.	Investigators. a.
FATS (ANIMAL).				
Fat of swine,		9,476.9	2	St. & L.
Do.		9,380.0	2,3	St.
Do.		9,686.0	2	D.
Do.		9,423.0	1,2	R.
Do.		9,515.0	2	Gi.
Fats of oxen,		9,485.7	2	St. & L.
Do.		9,357.0	2,3	St.
Do.		9,427.0	2	Gi.
Do.		9,686.0	1	D.
Fats of sheep,		9,493.6	2	St. & L.
Do.		9,406.0	2,3	St.
Do.		9,530.0	2	Gi.
Fat of horse,		9,410.0	2	St.
Fat of dog,		9,330.0	2	St.
Fat of goose,		9,345.0	2	St.
Fat of duck,		9,324.0	2	St.
Fat of man,		9,398.0	2	St.
Sperm oil,		10,001.0	2	Gi.
Butter fat,		9,215.8	2	St. & L.
Do.		9,192.0	2,3,10	St.
Do.		9,185.0	2	Gi.
Do.		9,231.3	8	
Do.		9,179.0	1	St.
Do.		9,230.0	10	St. & L.
Fat, mean (man, oxen, sheep),		9,365.0	10	St.
Fat, mean (dog, swine),		9,423.0	10	R.
Fat, mean (goose, duck),		9,500.0	10	St. & L.
Do.		9,372.0	1	St.
FATS (VEGETABLE).				
Olive oil (expressed),		9,328.0	2,10	St.
Do.		9,471.0	2	Gi.
Do.		9,328.0	3	St.
Do.		9,467.0	8	
Do.		9,455.0	1	St.
Do.		9,471.0	2	St.
Do.		9,442.0	10	St.
Poppy-seed oil,		9,489.0	2,10	St.
Rape-seed oil,		9,489.0	2,10	St.
Do.		9,619.0	2,10	St.
Do.		9,621.9	10	M.
Ether extract—Various seeds,		9,130.0 9,467.0	2	St.
CARBOHYDRATES, ETC.				
Arabinose,	$C_5H_{10}O_5$	3,714.0	2,6,10	B. & M.
Do.	$C_5H_{10}O_5$	3,722.0	8,2,6,10	St. & L.
Do.	$C_5H_{10}O_5$	3,695.0	5,2,10,4	St.
Xylose,	$C_5H_{10}O_5$	3,739.9	2,6,10	B. & M.
Do.	$C_5H_{10}O_5$	3,746.0	2,8,6,10	St. & L.
Fucose	$C_6H_{12}O_5$	4,340.9	2,6,10	St. & L.
Rhamnose (water free),	$C_6H_{12}O_5$	4,379.3	2,6,10	St. & L.
Rhamnose (crystallized),	$C_6H_{12}O_5H_2O$	3,909.2	2,6,10	St. & L.
Sorbinose,	$C_6H_{12}O_6$	3,714.5	2,6,10	St. & L.
Galactose,	$C_6H_{12}O_6$	3,721.5	2,6,10	St. & L.
Do.	$C_6H_{12}O_6$	3,659.0	2,4	St.
Dextrose (glucose),	$C_6H_{12}O_6$	3,762.0	2,4	B. & V.
Do.	$C_6H_{12}O_6$	3,742.6	2,8,6,10	St. & L.
Do.	$C_6H_{12}O_6$	3,692.0	2,4,5,10,1	St.
Do.	$C_6H_{12}O_6$	3,754.0	2,10	Gi.
Do.	$C_6H_{12}O_6$	3,939.0	1	Rch.
Do.	$C_6H_{12}O_6$	3,760.0	6	B.
Dextrose (hydrated),	$C_6H_{12}O_6H_2O$	3,567.0	1	Rch.
Levulose (fructose).	$C_6H_{12}O_6$	3,755.0	2,8,6,10	St. & L.
Glucoheptose,	$C_7H_{14}O_7$	3,732.8	2,10	B. & F.
Cane sugar (sucrose),	$C_{12}H_{22}O_{11}$	3,961.7	2,4,10,9	B. & V.
Do.	$C_{12}H_{22}O_{11}$	3,955.2	8,2,6,9,10	St. & L.
Do.	$C_{12}H_{22}O_{11}$	3,866.0	2,5,10	St.
Do.	$C_{12}H_{22}O_{11}$	4,001.0	2,10	Ru.
Do.	$C_{12}H_{22}O_{11}$	3,921.0	2,10	Gi.
Do.	$C_{12}H_{22}O_{11}$	3,958.7	9	T.
Do.	$C_{12}H_{22}O_{11}$	4,176.0	1	D.
Do.	$C_{12}H_{22}O_{11}$	4,173.0	1	Rch.
Do.	$C_{12}H_{22}O_{11}$	3,959.0	1	St.
Do.	$C_{12}H_{22}O_{11}$	3,908.0	4	St.
Milk sugar (lactose),	$C_{12}H_{22}O_{11}$	3,951.5	2,6,10	St. & L.
Do.	$C_{12}H_{22}O_{11}$	3,877.0	1,2,4,5,10	St.
Do.	$C_{12}H_{22}O_{11}$	4,162.0	1	Rch.
Do.	$C_{12}H_{22}O_{11}$	3,920.0	10	Gi.
Milk sugar hydrated,	$C_{12}H_{22}O_{11}H_2O$	3,777.1	2,10	B. & V.
Do.	$C_{12}H_{22}O_{11}H_2O$	3,736.8	2,8,6,10	St. & L.
Do.	$C_{12}H_{22}O_{11}H_2O$	3,663.0	2,4,10	St.

Substances.	Formulas.	Calories.	References. a.	Investigators. a.
Do.	$C_{12}H_{22}O_{11}H_2O$	3,710.0	2	Gi.
Do.	$C_{12}H_{22}O_{11}H_2O$	3,945.0	1	Rch.
Do.	$C_{12}H_{22}O_{11}H_2O$	3,667.0	1	St.
Do.	$C_{12}H_{22}O_{11}H_2O$	3,772.2	4	B.
Do.	$C_{12}H_{22}O_{11}H_2O$	3,721.8	6	Gi.
Do.	$C_{12}H_{22}O_{11}H_2O$	3,724.0	10	Gi.
Maltose,	$C_{12}H_{22}O_{11}$	3,949.3	2,8,6,10	St. & L.
Do.	$C_{12}H_{22}O_{11}$	4,163.0	1	Rch.
Maltose hydrated,	$C_{12}H_{22}O_{11}H_2O$	3,721.8	2,6,10	St. & L.
Do.	$C_{12}H_{22}O_{11}H_2O$	3,932.0	1	Rch.
Trehalose,	$C_{12}H_{22}O_{11}$	3,947.0	2,10,6	St. & L.
Trehalose hydrated,	$C_{12}H_{22}O_{11}H_2O$	3,550.3	2,10,6	St. & L.
Raffinose (melitriose),	$C_{18}H_{32}O_{16}$	3,928.0	10	St.
Do.	$C_{18}H_{32}O_{16}$	4,020.0	2,6,10	B. & M.
Do.	$C_{18}H_{32}O_{16}$	4,020.8	2,6,10	St. & L.
Raffinose (melitriose) hydrated,	$C_{18}H_{32}O_{165}$ (H_2O)	3,460.2	2,6	St.
Do.	$C_{18}H_{32}O_{165}$ (H_2O)	3,399.1	10	St. & L.
Melitose,	$C_{12}H_{22}O_{11}$	3,880.0	4	St.
Do.	$C_{16}H_{32}O_{16}$	4,122.2	5	St.
Melezitose,	$C_{18}H_{34}O_{17}$	3,913.7	2,6,10	St. & L.
Glycogen,	$(C_6H_{10}O_5)n$	4,190.6	2,6	St. & L.
Cellulose,	$(C_6H_{10}O_5)n$	4,200.0	2,4	B. & V.
Do.	$(C_6H_{10}O_5)n$	4,185.4	2,6,10	St. & L.
Do.	$(C_6H_{10}O_5)n$	4,146.0	1,2,4,10	St.
Do.	$(C_6H_{10}O_5)n$	4,152.9	6	Go.
Do.	$(C_6H_{10}O_5)n$	4,155.0	10	Go.
Do.	$(C_6H_{10}O_5)n$	4,205.0	10	B. & V.
Dextrin (dextran),	$(C_6H_{10}O_5)n$	4,180.4	2,10	B. & V.
Do.	$(C_6H_{10}O_5)n$	4,112.3	2,10,6	St. & L.
Starch,	$(C_6H_{10}O_5)n$	4,228.0	2,4,10	B. & V.
Do.	$(C_6H_{10}O_5)n$	4,182.5	2,6,10	St. & L.
Do.	$(C_6H_{10}O_5)n$	4,123.0	2,4,10	St.
Do.	$(C_6H_{10}O_5)n$	4,164.0	2,6,10	Gi.
Do.	$(C_6H_{10}O_5)n$	4,479.0	1	Rch.
Do.	$(C_6H_{10}O_5)n$	4,116.0	1	St.
Inulin,	$(C_6H_{10}O_5)n$	4,187.1	2,10	B. & V.
Do.	$(C_6H_{10}O_5)n$	4,133.5	2	St. & L.
Do.	$(C_6H_{10}O_5)n$	4,070.0	2,4,10	St.
Do.	$C_{36}H_{60}O_{31}$	4,133.5	6,10	St.
ALCOHOLS.				
Methyl alcohol (liquid),	CH_4O	5,260.7	5	
Do.	CH_4O	5,307.1	10	F. & S.
Do.	CH_4O	5,321.5	10	St. & L.
Methyl alcohol (gas),	CH_4O	5,693.7	10,5	Th.
Ethyl alcohol (liquid),	C_2H_6O	7,068.0	2,10	B. & M.
Do.	C_2H_6O	7,183.6	3,10,1	F. & S.
Do.	C_2H_6O	6,980.0	1	B.
Do.	C_2H_6O	7,095.0	9	A.
Do.	C_2H_6O	7,044.0	5	St.
Ethyl alcohol (gas),	C_2H_6O	7,402.2	10	Th.
Do.	C_2H_6O	7,321.7	10	B. & M.
Do.	C_2H_6O	7,394.1	5,7	
Propyl alcohol (liquid),	C_3H_8O	8,010.3	5	St.
Do.	C_3H_8O	8,005.2	10	Lu.
Propyl alcohol (gas),	C_3H_8O	8,310.0	10	Th.
Do.	C_3H_8O	7,301.7	5,7	
Amyl alcohol,	$C_5H_{12}O$	8,958.6	10	F. & S.
Do.	$C_5H_{12}O$	9,021.8	10	Lu.
Do.	$C_5H_{12}O$	9,005.7	5	St.
Glycerin,	$C_3H_8O_3$	(4,112.4)	2	St. & L.
Do.	$C_3H_8O_3$	4,312.4	10	St. & L.
Do.	$C_3H_8O_3$	4,317.0	2,10	St.
Do.	$C_3H_8O_3$	4,305.0	1	St.
Do.	$C_3H_8O_3$	4,265.2	10	Lu.
Erythrit,	$C_4H_{10}O_4$	4,075.0	10	St.
Do.	$C_4H_{10}O_4$	4,112.5	10	Lu.
Do.	$C_4H_{10}O_4$	4,117.6	10	B. & M.
Do.	$C_4H_{10}O_4$	4,131.3	10	St. & L. & K.
Do.	$C_4H_{10}O_4$	4,132.3	10,6	St. & L.
Do.	$C_4H_{10}O_4$	4,072.7	5	St.
Mannite,	$C_6H_{14}O_6$	4,001.2	2,4,10	B. & V.
Do.	$C_6H_{14}O_6$	3,997.8	2,6,10	St. & L.
Do.	$C_6H_{14}O_6$	3,908.0	2	St.
Do.	$C_6H_{14}O_6$	3,959.0	2,6,10	Gi.
Do.	$C_6H_{14}O_6$	3,939.0	10	St.
Do.	$C_6H_{14}O_6$	3,936.6	5,10	St.
Arabit,	$C_5H_{12}O_5$	4,024.6	6,10	St. & L.
Dulcit,	$C_6H_{14}O_6$	3,975.9	6,10	St. & L.
Do.	$C_6H_{14}O_6$	4,006.0	4,10	B. & V.
Do.	$C_6H_{14}O_6$	3,905.9	5	St.
Quercite,	$C_6H_{12}O_5$	4,293.6	6	St.
Do.	$C_6H_{12}O_5$	4,329.0	6	B.
Inosite,	$C_6H_{12}O_6$	3,679.6	6	St.
Do.	$C_6H_{12}O_6$	3,695.1	6	B.

Substances.	Formulas.	Calories.	References. a.	Investigators. a.
ACIDS.				
Fomic acid (liquid),	CH_2O_2	1,271.2	5	St.
Do.	CH_2O_2	1,366.8	10	J.
Do.	CH_2O_2	1,347.8	10	B.
Formic acid (gas),	CH_2O_2	1,508.5	10	Th.
Acetic acid,	$C_2H_4O_2$	3,490.4	2	B. & M.
Do.	$C_2H_4O_2$	3,505.2	1,10	F. & S.
Do.	$C_2H_4O_2$	3,498.3	7	
Do.	$C_2H_4O_2$	3,553.2	5	St.
Do.	$C_2H_4O_2$	3,480.0	10	J.
Do.	$C_2H_4O_2$	3,555.0	10	St. & R.
Acetic acid (gas),	$C_2H_4O_2$	3,755.0	10	Th.
Propionic acid,	$C_3H_6O_2$	4,968.2	5	St.
Butyric acid,	$C_4H_8O_2$	5,936.9	5	St.
Do.	$C_4H_8O_2$	5,647.0	1,10	F. & S.
Do.	$C_4H_8O_2$	5,939.8	10	St. & Ro.
Oxybutyric acid,	$C_4H_8O_3$	4,536.0	10	Lu.
Palmetic acid,	$C_{16}H_{32}O_2$	9,352.9	2,10	St. & L.
Do.	$C_{16}H_{32}O_2$	9,226.0	2,10	St.
Do.	$C_{16}H_{32}O_2$	9,216.8	5	St.
Do.	$C_{16}H_{32}O_2$	9,264.8	10	Lu.
Do.	$C_{16}H_{32}O_2$	9,316.5	10	F. & S.
Stearic acid,	$C_{18}H_{36}O_2$	9,429.0	2,10	St.
Do.	$C_{18}H_{36}O_2$	9,716.5	1,10	F. & S.
Do.	$C_{18}H_{36}O_2$	9,412.0	1	St.
Do.	$C_{18}H_{36}O_2$	9,886.0	1	Rch.
Do.	$C_{18}H_{36}O_2$	9,745.0	1	R.
Oleic acid,	$C_{18}H_{34}O_2$	9,494.9	10	St. & L.
Malonic acid,	$C_3H_4O_4$	1,998.2	2,10	B. & Lu.
Do.	$C_3H_4O_4$	1,960.0	2	St.
Do.	$C_3H_4O_4$	1,998.3	10	St. & L.
Succinic acid,	$C_4H_6O_4$	3,006.2	2,10	B. & Lu.
Do.	$C_4H_6O_4$	3,019.0	2	St.
Do.	$C_4H_6O_4$	2,996.0	1	Rch.
Do.	$C_4H_6O_4$	2,937.0	1	St.
Do.	$C_4H_6O_4$	3,026.3	10	St. & L.
Tartaric acid,	$C_4H_6O_6$	1,745.0	1,2	St.
Do.	$C_4H_6O_6$	1,407.0	1	Rch.
Citric acid,	$C_6H_8O_7$	2,477.9	2,10	B. & Lu.
Do.	$C_6H_8O_7$	2,397.0	2,10	St.
Do.	$C_6H_8O_7$	2,477.9	2,10	B. & Lu.
Citric acid, hydrated,	$C_6H_8O_7H_2O$	2,250.4	10	Lu.
Oxalic acid,	$C_2H_2O_4$	659.0	1	Rch.
Do.	$C_2H_2O_4$	569.0	1	St.
Do.	$C_2H_2O_4$	571.0	10	St.
Do.	$C_2H_2O_4$	678.6	10	St. & L.
Do.	$C_2H_2O_4$	672.5	10	J.
Benzoic acid,	$C_7H_6O_2$	6,360.5	5	St.
Do.	$C_7H_6O_2$	6,322.3	9	St. & L.
Do.	$C_7H_6O_2$	6,322.1	9	B. & Lu.
Do.	$C_7H_6O_2$	6,281.0	10	St.
Do.	$C_7H_6O_2$	6,315.0	10	St. & Ro.
Do.	$C_7H_6O_2$	6,345.0	10	B. & Re.
Do.	$C_7H_6O_2$	(7,663.0)	5	St.
Salicylic acid,	$C_7H_6O_3$	7,236.0	5	St.
Do.	$C_7H_6O_3$	5,286.2	10	St. & L.
Do.	$C_7H_6O_3$	5,326.0	10	B. & Re.
HYDBROCARBONS, ETC.				
Methane,	CH_4	13,063.0	3,10	F. & S.
Do.	CH_4	13,218.9	5,7	Th.
Do.	CH_4	13,243.7	10	Th.
Do.	CH_4	13,275.0	10	B.
Ethane,	C_2H_6	12,144.2	7,5	
Do.	C_2H_6	12,346.7	10	Th.
Do.	C_2H_6	12,991.7	10	B.
Propane,	C_3H_8	12,027.3	10	Th.
Do.	C_3H_8	12,543.0	10	B.
Do.	C_3H_8	12,582.0	5,7	
Acetylene,	C_2H_2	11,919.7	7	Th.
Do.	C_2H_2	11,923.0	10	Th.
Do.	C_2H_2	12,112.0	10	B.
Ethlyene,	C_2H_4	11,858.0	3,10	F. & S.
Do.	C_2H_4	11,894.4	7,5	
Do.	C_2H_4	11,883.6	10	Th.
Do.	C_2H_4	12,154.0	10	B.
Propylene,	C_3H_6	11,730.0	10	Th.
Do.	C_3H_6	12,045.0	10	B.
Do.	C_3H_6	11,717.0	5,7	
Benzol (benzine),	C_6H_6	9,949.0	10	B.
Do.	C_6H_6	9,977.5	10	St. & L.
Do.	C_6H_6	9,997.0	10	St., Ro. & He.

Substances.	Formulas.	Calories.	References. a.	Investigators. a.
Benzol (gas),	C_6H_6	10,041.0	10	B. & Og.
Do.	C_6H_6	10,096.0	10	St., Ro. & He.
Do.	C_6H_6	10,247.4	10	Th.
Napthalene,	$C_{10}H_8$	9,628.0	9,10	St. & L.
Do.	$C_{10}H_8$	9,618.7	10	St. & L.
Do.	$C_{10}H_8$	9,664.0	10	B. & R.
Do.	$C_{10}H_8$	9,700.0	10	B. & Lu.
Do.	$C_{10}H_8$	9,718.0	10	B. & V.
Do.	$C_{10}H_8$	9,773.0	10	Ru.
Camphor (inactive solid),	$C_{10}HO_{16}O$	9,298.7	10	Lu.
Do.	$C_{10}HO_{16}O$	9,291.6	9	St.
Do.	$C_{10}HO_{16}O$	9,288.0	9	B.

Nearly all of these results were obtained by burning the substance in oxygen gas in the bomb; but if we examine and compare the heat values obtained by different investigators with the same compound, and note how one author quotes the results of one, and another those of a second investigator as being the correct ones, we reach but one conclusion, namely, that some one is wrong. Two different results can not both be correct. The differences are in many instances so great that they can not possibly be ascribed to impure substances or ordinary analytical errors due to drying, weighing, etc. But who will take the responsibility of saying that one investigator is right and another wrong? Or that so much of one man's work and so much of the work of some one else is correct? Each of the two men whose names appear most frequently (Stohmann and Berthelot) has a large following. Many will accept Stohmann's results before those of anyone else, and the same may be said of Berthelot; yet there is nothing which indicates that there was some particular fault in the operation of one distinct from the other, for in some cases Stohmann and in others Berthelot, has the higher figures for the same substance.

Judging from the records of the different investigators the most that can be said is that with a few substances we have the heats of combustion to within the limits of analytical error, but with the majority only approximately so, and with a few not even that.

Evidently there is need of a revision in the heat values of organic substances so that only the reliable, or at least nearly correct, values should find their way into the tables of text-books, etc., and the faulty ones be dropped. Until such a systematic checking up of the older results by means of the very best and most modern apparatus has been done, the bomb calorimeter should be used freely in all investigations where the heats of combustion play a part, and the values found by actual determinations should be preferred to those obtained or computed from general tables. The bomb thermometer

may also to a limited extent serve as a standard with which other thermometers in use may be compared.

VARIATIONS IN DETERMINATIONS ALREADY ON RECORD.

In order to make these figures a little plainer and to put the matter in more compact form I have selected some of the more common compounds from the previous table, and, placing the highest reported heat of combustion of a substance at 100, have shown in the following table the difference between it and the lowest result obtained by some other investigator:

TABLE II.—Difference between the highest and lowest results on some common compounds referred to in Table I.

Substance.	Number of investigators.	Difference.	Substance.	Number of investigators.	Difference.
Hydrogen,	8	1.86	Cane sugar,	9	6.42
Charcoal,	4	4.53	Milk sugar,	4	6.85
Sulphur,	4	4.53	Milk sugar, hydrated,	9	7.17
CO to CO_2,	5	1.60	Maltose,	2	5.13
Hemoglobin,	5	1.09	Maltose, hydrated,	2	5.35
Milk casein,	8	4.10	Cullulose,	6	1.40
Egg albumin,	4	2.72	Starch,	6	2.65
Blood fibrin,	7	4.52	Inulin,	3	2.75
Peptone,	4	7.98	Methyl alcohol, liquid,	3	1.13
Chondrin,	3	8.11	Ethyl alcohol, liquid,	5	2.83
Urea,	6	16.53	Glycerin,	3	1.20
Glycocoll,	4	2.67	Mannite,	5	2.33
Hippuric acid,	3	.46	Acetic acid,	6	2.11
Asparagin,	3	3.34	Palmitic acid,	5	1.46
Uric acid,	4	4.83	Stearic acid,	5	4.80
Fat of swine,	5	3.16	Oxalic acid,	5	16.08
Fat of oxen,	4	3.40	Benzoic acid,	6	1.25
Butter fat,	6	.57	Methane,	4	1.60
Olive oil,	7	1.56	Benzol liquid,	3	.48
Arabinose,	3	.73	Benzol gas,	3	2.02
Galactose,	2	1.68	Naphthalene,	6	1.58
Dextrose,	6	1.86	Camphor,	3	.12

In chemical-laboratory work, whether it be by advanced students or professional chemists, it is required that the work of the analyst shall be within certain limits of error, varying, naturally, with the nature of the substance analyzed and the method employed. No fixed rule can be laid down as to the limits of error allowed, but for most of the more common substances such as oxides, carbonates, many ores and clays, etc., some of which have many ingredients to be determined, the total of the determinations must come, barring exceptional cases, within, say, about 99.75 per cent. and 100.5 per cent., in order to be accepted. The extent to which the results obtained by different analysts on a single ingredient are allowed to vary is very variable. In a determination like that of total nitrogen, for example, the substance containing 18 per cent. nitrogen, two analysts should come not farther than about 0.05 or 0.06 per cent. apart in

the results obtained, except for special reasons. Such a variation as, for instance, between 17.97 per cent. and 18.03 per cent. nitrogen would be equal to 0.33 per cent. difference between the analysts.

Of the 44 cases just cited in Table II the difference between the results obtained by different investigators is below 1 per cent. for only five substances. With most of the substances the analysts are several points apart, and in urea and oxalic acid there are differences of over 16 per cent.

That two determinations by the same analyst agree when the same quantity of the sample is used, under exactly the same conditions and manipulations, it no guaranty that the method is perfect or the result correct. If, on the other hand, results agree when charges varying in weight have been used under somewhat varying conditions within the working limits of the method, we feel more sure about their being correct.

CAUSES OF DIFFERENCES IN HEAT DETERMINATIONS.

The method for the determination of heat values of substances can not be considered perfect until work can be done as accurately as is possible, in ordinary chemical analyses at least.

From the heat values given, we are led to question: What can have caused these differences in the past? What causes differences at present?

Following the directions given in Wiley's Principles and Practice of Agricultural Analysis, Volume III, a number of determinations had been made in this laboratory by means of the apparatus already described, using the commercial oxygen gas found on the market, put up in iron cylinders under very high pressure. The water equivalent of the whole bomb system had been determined by burning cellulose and cane sugar in oxygen under 20 atmospheres' pressure in the bomb, 4,185 calories per gram being the heat value used for the cellulose and 3,955.2 calories per gram for the sugar. The average of a large number of determinations had given the value as 430 grams, and since exactly 2,000 grams of water was used in all cases, the factor was 2,430.

Apparently there was no difficulty in obtaining concordant results when like charges were burned, but with varying charges the work was not satisfactory. The analytical error with a small charge may of course magnify the percentage error but excluding this possibility it should be possible with a small charge to obtain results indentical with those obtained from a larger charge of the same material. To say that 4,000 to 5,000 calories should be generated in the bomb in order to give good results, and that with only 2,000 calories the work is not satisfactory is to say that the entire method is unreliable.

IMPURE OXYGEN.

Some difficulties which were experienced in elementary carbon and hydrogen determinations in which the same oxygen was used, led to the examination of the oxygen for impurities in the form of combustible gases. It was found beyond a doubt that such impurities were present in the oxygen in quantity sufficient to be reckoned with, and the magnitude of the error caused by them will be referred to further on.

Now arose the questions: To what extent do these combustible gases influence the working of the bomb calorimeter? Is the water value of the bomb, determined by the use of this impure oxygen, correct? Can a correction and the water value be worked out correctly?

TESTING OF OXYGEN.

In order to give the apparatus a severe test, and to try to work out an answer to some of these questions, using the impure oxygen itself for the purpose, the following method was adopted: Cellulose was chosen as the chief substance to be burned, and sugar in the form of rock candy was also used. By burning small charges of pure cellulose absorption blocks in the bomb calorimeter, charged with oxygen at various pressures, it was hoped that any increase found with the greater pressure of oxygen would represent the total impurity in the additional amount of oxygen equivalent to the increased pressure, and that, having ascertained the correction for impurities, it could be applied and the water value of the bomb worked out without difficulty. Cellulose, although a very hygroscopic substance, and on that account difficult to handle, was chosen for this work because it ignites readily and burns quickly and completely in a comparatively small excess of oxygen. It represents the main class of substances whose heats of combustion are determined in our work, and its heat value is fairly well established. Sugar, on the other hand, is a substance which does not ignite readily and which burns more slowly, often leaving a trace of unburned carbon even with plenty of oxygen.

It was soon learned that the combustible gases in the oxygen were not oxidized completely, and perhaps never can be fully burned in a bomb calorimeter, but the tests were carried out as planned. The problem was not so simple as at first thought, but it was hoped that the oxidation of the gases referred to would be in proportion to the density of the gas mixture or the heat generated in the bomb. This is by no means a perfect method, but it may be a means of helping over the difficulty when no pure oxygen or other means for comparison are at hand.

One lot of oxygen (Oxygen I) was tested with both cellulose and sugar in the manner described. A second lot (Oxygen II) was tested

only with cellulose. In every instance the cellulose was dried at between 103° and 105°. C., to constant weight.

The effect of the impurities may be seen in Tables III to VII, where the corrected rises in temperature will indicate the differences due to more or less oxygen and to the amount of heat generated in the bomb. But before we discuss these results we may examine Table III, where we find the heats of combustion of the various substances worked out as in the course of ordinary routine work, using the water value 430 for the bomb system. This value plus the 2,000 grams of water used makes the factor for the bomb system plus water equal to 2,430 grams.

The column headed "Total computed calories," refers to all the heat generated in the bomb, and includes the heat represented by the substance and the iron wire burned, the nitric acid formed and dissolved, and the heat due to the electric current whenever it failed to ignite the substance instantly.

Varying amounts of oxygen will change the water value of the system; hence in all cases where more or less than 20 atmospheres oxygen was used the temperature rises have been corrected to 20 atmospheres oxygen pressure. For this bomb—of about 360 c. c. capacity—the correction for 1 atmosphere oxygen is ±0.0046 per cent. of the observed rise in temperature. Thus, taking for example the first rise referred to in Table III, the rise due to the burning of 0.5092 gram sugar in 10 atmospheres oxygen, corrected to 20 atmospheres oxygen, will be:

	°C.
Observed rise in temperature,	0.8488
Correction for 10 atmospheres oxygen,	.00039
Corrected rise,	.84841

The heat values accepted for the following substances, and used in the computations of the bomb-water values given in Table III, are:

	Calories per gram.
Cellulose,	4,185.0
Sugar,	3,955.2
Naphthalene,	9,628.0
Camphor,	9,290.0
Benzoic acid,	6,322.0

The water values of the bomb as found worked out in Table III have not been used in any computation, but they will indicate how widely the individual values vary from 430— the value used in the calculations of heats of combustion.

TABLE III.—Water value of the bomb calorimeter and heat value per gram of substance, worked out by using the water value 430.[a]

Substance.	Lot of oxygen used.	Oxygen pressure.	Weight of substance.	Total computed.	Rise corrected for oxygen, 20 atmosphere.	Bomb water value.	Calories per gram.
		Atmospheres.	Grams.	Calories.	°C.		
Sugar, ...	I,....	10	0.5092	2,050.26	0.8484	416.6	3,976.0
		10	.5019	2,013.96	.8352	411.3	3,983.1
		24	.5054	2,038.32	.8493	400.1	4,005.4
		24	.5096	2,046.35	.8558	390.1	4,020.2
		24	1.0000	4,106.14	1.7037	410.0	3,986.6
Cellulose, ...	I,....	10	.3799	1,617,47	.6671	424.6	4,194.4
		10	.3840	1,628.16	.6746	413.5	4,213.8
		10	.3711	1,571.58	.6484	423.8	4,193.3
		15	.3789	1,604.70	.6678	403.1	4,232.3
		20	.3800	1,609.68	.6734	390.4	4,255.2
		20	.3737	1,584.11	.6604	398.7	4,240.2
		20	.3714	1,574.21	.6558	400.4	4,237.2
		20	.6800	2,868.06	1.1896	410.9	4,218.3
Cellulose, ...	II,...	10	.4358	1,802.34	.7381	442.0	4,164.1
		10	.4257	1,803.55	.7395	438.7	4,169.8
		24	.4253	1,824.37	.7489	435.9	4,174.5
		24	.4276	1,815.50	.7450	436.8	4,173.4
		24	.6675	2,817.39	1.1579	433.1	4,179.5
		24	1.0035	4,229.14	1.7492	417.7	4,206.4
Naphthalene, ...	II,...	20	.5274	5,108.42	2.1111	419.8	9,668.9
		20	.5430	5,255.04	2.1785	412.2	9,699.3
Camphor, ...	II,...	20	.4671	4,360.28	1.7985	424.4	9,311.6
		20	.5034	4,703.37	1.9409	423.3	9,315.8
Benzoic acid, ...	II,...	20	.6986	4,438.67	1.8390	413.6	6,365.1
		20	.7027	4,473.37	1.8520	415.4	6,360.4

a No correction for impurities in oxygen is applied.

These determinations, too few in number for very good averages, were made now and then as other work permitted; hence they cover months of time. A hasty glance over these figures would be enough to condemn the apparatus as being useless for accurate work or the investigator as being unskilled or careless. Of course the analytical errors of the small charges will, as already said, be magnified; hence the duplicates may not always agree closely. Looking a little closer at the table, we notice that all the different groups—that is, those which were treated alike as to quantity of substance and the amount of oxygen—agree fairly well, thus proving that the differences between the groups are not due to careless manipulation. The reason for the disagreements must be sought for elsewhere.

But how are we to interpret the figures, which, in some cases, apparently contradict each other? In the column giving calories per gram we find in the case of cellulose an extreme difference of over 2 per cent. in the heat of combustion. Further, we notice that 0.5 gram sugar burned in 10 atmospheres oxygen gave as high results as when 1 gram sugar was burned in 24 atmospheres oxygen. Again, in the case of cellulose in Oxygen I, the smaller charges at 20 atmospheres oxygen gave higher results than the larger charge at the same oxygen pressure, whereas in the case of Oxygen II the opposite is shown.

Another vary marked peculiarity in the results is that, with the same factor for the bomb, etc., and the same kind of cellulose, in the work with Oxygen I, all the results on both sugar and cellulose are above the accepted values—sugar as much as 1.6 per cent. and cellulose up to 1.64 per cent. In Oxygen II, on the other hand, all the cellulose results, except the one where over 1 gram cellulose charge was used, are below the accepted heat value; but the naphthalene, camphor, and benzoic acid are all above—naphthalene about 0.7 per cent. camphor about 0.3 per cent., and benzoic acid about 0.7 per cent. It should be mentioned here, however, that these substances, while bought as chemically pure, were not tested for impurities before using.

Looking at the column giving the water values of the bomb, we find a corresponding variation, most of the values being below the one used (430), ranging anywhere from 390 to 442.

If a general view is taken of the various results and the behavior of the substances under different conditions, we are convinced that the oxygen contains considerable impurity in the form of combustible gases, for which corrections must be applied. This being the case, the old, apparently too high, water value (430) of the bomb will not be high enough.

CORRECTION FOR IMPURITY IN THE OXYGEN.

Is the correction a constant quantity? Is it of any value to know the total amount of carbon and hydrogen present as combustible gases in the oxygen? These are some of the questions which now concern us as we endeavor to work out the water value of the bomb system, applying the corrections as found for the oxygen and for the amount of heat generated in the bomb.

We turn our attention to Tables IV to VII and examine first the work with cellulose, Oxygen I. From Table IV we learn that between the averages computed to be due to like charges burned in ten atmospheres oxygen pressure and 20 atmospheres there is a slight difference in the rise in temperature in favor of the greater amount of oxygen. This difference does not represent the total impurity in that amount of oxygen, but only the amount which will be oxidized under the specific conditions of so much cellulose and so much oxygen. The difference in rise in temperature, when about 1,600 calories were generated in the bomb, was 0.000665° C. for 1 atmosphere oxygen.

TABLE IV.—Rise in temperature caused by burning like quantities of cellulose in the bomb calorimeter, in varying amounts of oxygen (Oxygen I).

Oxygen pressure.	Cellulose.	Fuse wire.	HNO_3.	Total computed.	Rise in temperature.	Rise corrected for oxygen, 20 atmosphere.	Rise due to 1,600 calories.
Atmospheres.	Grams.	Calories.	Calories.	Calories.	°C.	°C.	°C.
10,	3.3799	17.12	2.60	1,617.47	0.6674	0.6671	0.6599
10,	.3840	17.12	4.00	1,628.16	.6749	.6746	.6629
10,	.3711	16.48	2.00	1,571.58	.6487	.6484	.6601
15,	.3789	16.00	3.00	1,604.70	.6679	.6678	.6658
20,	.3800	15.68	3.70	1,609.68	.6734	.6734	.6694
20,	.3737	15.68	4.50	1,584.11	.6604	.6604	.6670
20,	.3714	16.00	3.90	1,574.21	.6558	.6558	.6665

	°C. rise.
1,600 calories in 20 atmospheres oxygen pressure,	0.66763
1,600 calories in 10 atmospheres oxygen pressure,	.66098
Difference,	.00665
Rise per atmosphere oxygen pressure,	.000665

Whether this error is uniform throughout—that is, whether the eleventh atmosphere oxygen, for instance, would show the same error as the twenty-first atmosphere with the same charge—can not be ascertained from these figures. At present we can only assume the error to be uniform.

Is this then the true correction to apply, no matter how large a charge was burned, or will more of the gases be oxidized in the same quantity of oxygen when more heat is generated?

Rock candy, Oxygen I.—In Table V we find a difference in the rise of temperature between 10 and 24 atmospheres oxygen pressure equal to 0.00045° C. per atmosphere when about 2,000 calories are generated in the bomb.

TABLE V.—Rise in temperature caused by burning like quantities of rock candy in the bomb calorimeter in varying amounts of oxygen (Oxygen I).

Oxygen pressure.	Rock candy.	Fuse wire.	HNO_3.	Total computed.	Rise in temperature.	Rise corrected for oxygen, 20 atmospheres.	Rise due to 2,000 calories.
Atmospheres.	Grams.	Calories.	Calories.	Calories.	°C.	°C.	°C.
10,	0.5092	18.08	3.25	2,050.26	0.8488	0.8484	0.8276
10,	.5019	16.80	3.15	2,013.96	.8356	.8352	.8293
24,	.5054	19.52	4.10	2,038.32	.8491	.8493	.8333
24,	.5096	13.16	4.50	2,046.35	.8556	.8558	.8364

	°C. rise.
2,600 calories in 24 atmospheres oxygen pressure,	0.83481
2,000 calories in 10 atmospheres oxygen pressure,	.82847
Difference,	.00634
Rise per atmosphere oxygen pressure,	.00045

Sugar, as has been said, does not always burn completely. Frequently a hardly weighable amount of carbon may be seen on the platinum capsule, a very small spot perhaps, yet it is an indication of incomplete combustion of the carbon itself and of the possibility that at least traces of intermediate partially oxidized products may be found.

Cellulose, Oxygen II.—In Table VI we find the results obtained with cellulose and another lot of oxygen. Here 1,800 calories produced in oxygen at 10 and 24 atmospheres pressure, a difference in temperature of only 0.00007° C. per atmosphere, which is within the limits of analytical error.

TABLE VI.—Rise in temperature caused by burning like quantities of cellulose in the bomb calorimeter in varying amounts of oxygen (Oxygen II).

Oxygen pressure.	Cellulose.	Fuse wire.	HNO_3.	Total computed.	Rise in temperature.	Rise corrected for oxygen, 20 atmospheres.	Rise due to 1,800 calories.
Atmospheres.	Grams.	Calories.	Calories.	Calories.	°C.	°C.	°C.
10,	0.4258	17.12	3.25	1,802.34	0.7384	0.7381	0.7371
10,	.4257	19.20	2.80	1,803.55	.7404	.7395	.7386
24,	.4253	21.12	5.00	1,824.37	.7488	.7489	.7389
24,	.4276	21.44	4.55	1,815.50	.7449	.7450	.7387

	°C. rise.
1,800 calories in 24 atmospheres oxygen pressure,	0.73884
1,800 calories in 10 atmospheres oxygen pressure,	.73778
Difference,	.00103
Rise per atmosphere oxygen pressure,	.00007

We have reason to believe, however, judging from the determinations referred to in Table III that this oxygen supply also was not pure, and hence we take up the question asked before: What effect has increased heat production upon the oxidation of these combustible gases?

For some of the following comparisons I must depend upon single determinations, which in itself is not very satisfactory; but since no more of the same oxygen is at hand for further work I must take for granted that the determinations are correct.

TABLE VII.—Comparison of observed rise in temperature due to the large and the calculated rise due to the smaller charges of a substance burned in the same quantity of oxygen.

Substance.	Lot of oxygen used.	Oxygen pressure.	Weight of substance.	Computed total.	Rise.	
		Atmospheres.	Grams.	Calories.	°C.	
Sugar,	I,	24	1.0000	4,106.14	1.70366	Observed.
		24	.5075	2,042.33	1.71396	Calculated.
				2,063.81	— .01020	Difference.
Cellulose,	I,	20	.6800	2,868.06	1.1896	Observed.
		20	.3750	1,589.30	1.1967	Calculated.
				1,278.76	— .0071	Difference.
Cellulose,	II,	24	1.0035	4,229.14	1.7492	Observed.
		24	.4265	1,819.93	1.7359	Calculated.
				2,409.21	+ .0133	Difference.
		24	.6675	2,817.39	1.1579	Observed.
		24	.4265	1,819.93	1.1564	Calculated.
				997.46	+ .0015	Difference.

In Table VII we find that when one gram of sugar was burned in 24 atmospheres oxygen, 4,106.14 calories of total heat being generated in the bomb, the rise in temperature of the bomb system was found to be 1.70366° C. The average rise in temperature found when 0.5075 gram of sugar was burned, or 2,042.33 calories of total heat was generated in the bomb, in the presence of 24 atmospheres oxygen, was 0.8525° C., and according to that the generation of 4,106.14 calories should have caused a rise of 1.71396° C. instead of 1.70366° C., as found when 1 gram was burned. The difference, therefore, is a minus of 0.0102° C. This indicates that, of the impurities in this particular oxygen, more were oxidized in proportion as the charge of sugar was reduced. Hence the correction referred to in Table V should not be increased in proportion to the increase in the amount of substance used.

With cellulose in Oxygen I a charge of 0.6800 gram, which, plus wire, etc., was equivalent to 2,868.06 calories total heat generated, gave a rise of 1.1896° C. instead of 1.1967° C. as it should have done according to the results upon the smaller charges. Here is also a minus difference of 0.0071° C., showing that this oxygen behaved the same with these two different substances. The combustible gases present in the oxygen must accordingly be of an easily combustible nature, comparatively speaking, when the increase in heat has no effect upon them above that of the lesser heat.

Next we examine the results obtained with different amounts of cellulose in Oxygen II. Here we see not a decrease, but a very

marked increase in the oxidation of combustible gases with increase in heat evolved. A charge of 0.6675 gram cellulose, or a total heat production of 2,817.39 calories, gave a rise in temperature of 1.1579° C., which is 0.0015° C. above what it should have been according to calculation from the results of the smaller charge of 0.4265 gram cellulose, equal to 1,819.93 calories total heat. When 1.0035 grams cellulose was burned there was a difference of 0.0133° C. above the calculated result. This difference in behavior of the two oxygen supplies toward larger charges of the substances burned indicated a difference in composition of the combustible gases in the oxygen. In Oxygen I the gases were apparently more readily oxidized than in Oxygen II, and therefore more of them burned with the small charges in proportion to what burned with the larger. The opposite would then be true of Oxygen II. Unfortunately no further and more definite proof can be given, since no qualitative tests were made of the gases. As to the impurities in Oxygen I being different from those in Oxygen II, there can be no doubt. In the first lot a strong, peculiar, disagreeable odor was noticed, and when the gases passed through pumice stones saturated with H_2SO_4 a slight yellow coloration was noticed for a short distance. Oxygen II had no such disagreeable odor and did not color the pumice stone as did Oxygen I.

According to analyses made by one of the assistant chemists of the experiment station, Oxygen I contained 0.0355 per cent. of hydrogen and 0.0150 per cent. of carbon by weight, while Oxygen II contained 0.0335 per cent. of hydrogen and 0.0150 per cent. of carbon. These results show that there must have been considerable free hydrogen present.

Not knowing the composition of the gases referred to, we may, for the sake of obtaining at least an approximate calorific value, assume that all the carbon is present as marsh gas, and that the excess of hydrogen is free hydrogen. Thus we have in Oxygen I 0.02004 per cent. CH_4 and 0.01446 per cent. free H_2, and in Oxygen II 0.02004 per cent. CH_4, and 0.01346 per cent. free H_2.

With 20 atmospheres oxygen, or in round numbers 10 grams of oxygen, these gases would represent in Oxygen I 73 calories, equivalent to 0.0299° C. rise, and in Oxygen II 69 calories, equivalent to 0.0283° C. rise.

In none of the determinations referred to with the above-mentioned, oxygen was more than about 45 per cent. of these figures reached, which can be seen in Table IV, where the correction for the impurities in 20 atmospheres oxygen equals 0.0133° C. This indicates plainly that only a part of the combustible gases mixed with the oxygen can be oxidized in the bomb.

RISE IN TEMPERATURE CORRECTED FOR HEAT DUE TO IMPURITIES IN THE OXYGEN.

In Table VIII following are given the corrected figures for the rise in temperature, also the values computed for the bomb-water value and for the heats of combustion of the substances, respectively. The corrected figures for the rise in temperature are obtained by using the results of Tables IV to VI. Thus the corrections used for the sugar and cellulose burned in Oxygen I are the differences found in Tables IV and V. No account has been taken of any increase in total heat formed in the bomb by use of larger amounts of material with Oxygen I.

For the smaller charges of cellulose burned in Oxygen II the differences found in Table VI have been used, and for the larger charges the increase in rise of temperature actually observed (Table VII) has been added to the first-mentioned correction. Thus, where 0.4253 gram cellulose was burned in Oxygen II the correction will be $0.00007° + 24 = 0.00168°$ C. For the charge of 0.6675 gram cellulose the correction will be $0.00168° + 0.0015°$ C., and for the largest amount of cellulose burned the correction equals 0.0151° C.

To all determinations of the other substances—naphthalene, camphor, and benzoic acid—where the total heat was a little higher than it was with the cellulose charge last mentioned, the same correction, 0.0151° C., has been applied.

The heats of combustion were computed by using the bomb-water value 439.2. This value is the average of those found for cellulose, naphthalene, camphor, and benzoic acid with Oxygen II. The average of all the results in Table VIII would be 437.8, but the values obtained with Oxygen I were not used on account of the sugar and cellulose not agreeing very closely.

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TABLE VIII.—Water value of the bomb calorimeter, and heat value per gram substance, worked out by using the new water value, 439.2, found after applying the corrections for the impurities in the oxygen.

Substance.	Lot of oxygen used.	Oxygen pressure.	Weight of substance.	Total computed.	Rise corrected for oxygen per 20 atmospheres.	Bomb water value.	Calories per gram.
		Atmospheres.	Grams.	Calories.	°C.		
Sugar,	I,	10	0,5092	2,050.26	0.8439	429.5	3,969.7
		10	.5019	2,013.96	.8307	424.4	3,976.4
		24	.5054	2,038.32	.8385	430.9	3,969.0
		24	.5096	2,046.35	.8450	421.7	3,984.2
		24	1.0000	4,106.16	1,7031	411.0	4,001.7
Cellulose,	I,	10	.3799	1,617.47	.6605	449.0	4,188.9
		10	.3840	1,628.16	.6678	438.1	4,186.9
		10	.3711	1,571.58	.6418	448.7	4,168.7
		15	.3799	1,604.70	.6578	439.5	4.184.8
		20	.3800	1,609.68	.6601	438.6	4.158.6
		20	.3737	1,584.11	.6471	448.0	4,170.1
		20	.3714	1,574.21	.6425	450.2	4,166.4
		20	.6800	2,868.06	1.1834	423.6	4,212.6
Cellulose,	II,	10	.4258	1,802.34	.7373	444.5	4,178.0
		10	.4257	1,803.55	.7388	441.2	4,181.5
		24	.4253	1,824.37	.7472	441.7	4,180.5
		24	.4276	1,815.50	.7433	442.5	4,179.0
		24	.6675	2,817.39	1.1548	439.7	4,184.1
		24	1.0035	4,229.14	1.7341	438.8	4,185.7
Naphthalene,	II,	20	.5274	5,108.42	2,0960	437.2	9,635.6
		20	.5430	5,255.04	2.1634	429.1	9,668.3
Camphor,	II,	20	.4671	4,360.28	1.7834	444.9	9,268.1
		20	.5034	4,703.37	1.9258	442.3	9,277.9
Benzoic acid,	II,	20	.6986	4,438.67	1.8239	433.6	6,336.6
		20	.7027	4 473.37	1.8369	435.3	6.332.1

The corrected results in Table VIII agree fairly well among themselves, and even where the conditions for determinations differed so widely from the ordinary they approach the heat values generally accepted for the substances used. This certainly could not be said when the impurities were not considered, as was seen in Table III, where a higher value was used than the average of the water values given in that table. From all that has been said on this topic we learn that, at best, the determination of the hydrothermo-equivalent, or water value, of the bomb with impure oxygen is no easy task, nor can it be very satisfactory. Hence the method explained can be recommended for use only where no pure oxygen —i. e., oxygen free from combustible gases—can be obtained.

FORMATION OF NITRIC ACID IN THE BOMB-CALORIMETER DURING COMBUSTION.

The formation of HNO_3 in the bomb has already been alluded to, also that correction must be made for the heat represented by the HNO_3 solution.

In the bomb there is always present more or less free nitrogen, and a portion of it is always oxidized, varying in quantity according to the nature of the substance burned, the total heat generated, and the

quantity of nitrogen in the bomb. This quantity of HNO_3, which appears to be constant for specific conditions, I propose to designate, for convenience, "bomb nitric acid," meaning thereby the HNO_3, expressed in calories, which would be formed in the bomb from free nitrogen during the combustion of a specified substance under specified conditions. Table IX, following, gives us an idea as to the value of this quantity for the oxygen used. This quantity, however, represents only a very small portion of the free nitrogen present in the bomb.

TABLE IX.—Formation of HNO_3 in the bomb calorimeter during combustion of nonnitrogenous substances.

Substance.	Determinations.	Oxygen.	Weight of substance.	Total heat.	HNO_3.	HNO_3 per 1,000 calories.
	Number.	Atmospheres.	Grams.	Calories.	Calories.	Calories.
Cellulose,	6	24	0.5481	2,335.2	6.74	2.89
Do.	7	20	.6550	2,763.9	6.50	2.35
Do.	6	10	.3946	1,677.4	3.01	1.79
Sugar,	4	24	.7538	3,016.4	6.13	2.04
Do.	7	20	1.2437	5,019.7	9.87	1.97
Do.	2	10	.5056	2,019.0	3.20	1.58
Naphthalene,	2	20	.5352	5,182.2	8.82	1.70
Camphor,	2	20	.4853	4,531.9	7.70	1.70
Benzoic acid,	2	20	.7007	4,454.6	7.55	1.70

In the last column of the foregoing table we see that this indifferent gas nitrogen behaves very much like the combustible gases present as impurities in the oxygen, namely, with an increase in quantity of oxygen, accompanied by an increase of free nitrogen, more nitrogen was oxidized. The individual determinations also showed a tendency to increased nitrogen oxidation with an increase in amount of substance burned.

For cellulose and the class of substances which it represents, such as feeds and feces, we can use, without introducing any appreciable error in the following calculations, a correction of 2.4 calories for each 1,000 calories total heat at 20 atmospheres oxygen pressure for the HNO_3 formed. For sugar and substances which would burn more like sugar than cellulose, such as gelatin, dried urine, milk, etc., we may use 2 calories per 1,000 calories total heat as the corresponding correction for the HNO_3 formed.

OXIDATION OF COMBINED NITROGEN TO NITRIC ACID.

It is generally assumed that the combined nitrogen in organic substances is set free as elementary nitrogen during a combustion. But in view of what has already been said we may be led to question

whether all, or at least part, of this nitrogen may not also be burned to HNO_3, perhaps even more readily so than the free nitrogen gas. It will be my object to take up the question of nitrogen of the substances to be analyzed, to see how much of this nitrogen is oxidized during a combustion, and what effect, if any, this will have upon the general results.

To illustrate the points which I want to bring out in this connection, and to make the tabulated figures more reliable, I have collected and taken the average of a large number of figures from work done at this station by Messrs. Norris and Carpenter on feeds, excreta, etc., the heats of combustion of which were mostly used in connection with the nutrition investigation experiments with cattle by means of the respiration calorimeter, referred to earlier in this paper. These data have served as the chief basis for the computations set forth in Table X. The substance in each charge was either a nitrogenous compound or mixed with one, so that in each case nitrogen was present in a combined form. From such a variety of substances we may expect to find some differences brought out as to the behavior in regard to the nitrogen, if any difference exists.

TABLE X.—Average HNO_3 formed during the combustion of various nitrogenous substances in the bomb calorimeter.

Substance.	Single determinations.	Average charge.	Total heat.	Nitrogen in charge.	Bomb HNO_3.	HNO_3 found.
	Number.	Grams.	Calories.	Grams.	Calories.	Calories.
Clover hay,	79	1.0178	4,355.8	.0183	10.45	5.68
Grain feed,	16	1.0031	4,508.9	.0342	10.82	9.51
Corn meal,	18	1.0046	4,252.9	.0167	10.21	9.38
Linseed meal,	11	1.0110	4,923.4	.0616	11.80	13.92
Feces,	70	1.0144	4,454.3	.0191	10.69	10.33
Hair and dandruff,	17	.8218	3,828.0	.0601	7.66	34.10
Gelatin,	5	.6601	2,671.4	.1188	5.34	12.42
Alcohol,+, Gelatin,	16	.6819 .2006	4,392.0 965.6	.0349	12.86	17.81
Urine,+ Much cellulose,	20	4.7571 .6623	1,182.8 2,771.7	.0462	7.91	.00
Urine,+ Little cellulose,	20	7.5178 .0508	1,548.3 212.8	.0478	3.52	1.78
Milk,+ Cellulose,	9	1.4648 .6596	1,103.9 2,760.4	.0079	9.27	9.22
Milk alone,	9	4.0354	3,327.9	.0225	6.66	9.17

In the above table we find, besides the amount of the sample used and the total heat produced in the bomb, the total nitrogen in the charge taken, the bomb nitric acid as calculated by using the values obtained in Table IX, and the actual HNO_3 found. It was assumed that the acidity in the bomb was due entirely to HNO_3. The figures represent the averages of numerous closely agreeing determinations;

in the case of hay, 79 single determinations. It may be stated here that the nitrogen represented by one calory is equal to 0.00098 gram, or to 0.004406 gram HNO_3.

From these figures, we learn first of all that the nitrogen behaves differently in different substances. Hair and dandruff, for instance, gave 4.5 times as much nitric acid as was due to the oxidation of the about twice as much total nitrogen in the sample, gave not much atmospheric nitrogen in the bomb, whereas gelatin, which contained about twice as much total nitrogen in the sample, gave not much more than one-third as much nitric acid as did the hair and dandruff, and only 2.3 times as much as the bomb nitric acid called for. In the case of urine plus considerable cellulose there was, strangely enough, no nitric acid found at all, yet about 8 calories should have been formed from the free nitrogen of the bomb alone. But with urine, plus a little cellulose, a small amount of HNO_3 was found. Naturally, one would expect more where more cellulose was used. These variations may introduce errors into the computations of the heat values of the substances, and in order to see the extent of these variations more clearly, and perhaps the probable errors, I have presented the results in another form in Table XI.

TABLE XI.—Errors due to the oxidation of nitrogen.

Substance.	Per cent. found of total HNO_3 possible	Nitrogen of sample oxidized to HNO_3.	Deviations from bomb HNO_3.	Errors of total calories of sample.
		Per cent.	Calories.	Per cent.
Clover hay,	19.47	0.0	— 4.77	0.11
Grain feed,	20.80	.0	— 1.31	.03
Corn meal	34.37	.0	— .83	.02
Linseed meal,	18.61	3.37	+ 2.12	.04
Feces,	34.18	.0	— .36	.01
Hair and dandruff,	49.56	43.02	+26.44	.70
Gelatin,	9.80	5.83	+ 7.08	.27
Alcohol+gelatin,	46.97	19.75	+ 4.95	.11
Urine+much cellulose,	.0	.0	— 7.91	.69
Urine+little cellulose,	3.40	.0	— 1.74	.11
Milk+cellulose,	56.39	.0	— .05	.00
Milk alone,	30.91	10.91	+ 2.51	.08

The bomb nitric acid plus the nitric acid represented by the oxidation of the total nitrogen of the charge is called 100, and in the first column of this table are found, expressed in percentages, the amounts formed of this possible HNO_3. In the second column is given the percentage of the nitrogen of the sample oxidized to HNO_3. The last two columns give the variations of nitric acid found from

the bomb HNO_3, and the percentage of the total heat values represented by this number of calories, as calculated from the determinations.

Several plus and several minus deviations from the computed bomb nitric acid are noticed in the preceding table. The minus signs force us to question: Was the full amount of bomb HNO_3 not formed, or was it formed and did it disappear again, changed into some other compound? The work done is not enough to answer this question fully, but I am strongly inclined to believe that the nitric acid was formed, but immediately on forming was changed into some other combination, probably through the influence of the ash ingredients.

In the bomb the nitric acid is found dissolved in the moisture which is condensed on the sides of the bomb. Here it may be mentioned that in transferring the nitric acid from the bomb to a beaker for titration care should be taken not to wash out the platinum capsule or add the ash to the rinsing. Often the ash is very strongly alkaline and would make the whole solution alkaline, which would be the same as having a minus quantity of acid formed—an impossibility.

This finding of the nitric acid and water together on the sides of the bomb would seem to indicate that the nitric acid is formed as a gas, and, together with the water in gaseous form, is expelled or driven from the seat of the great chemical activity or point of combustion to unite and condense with the moisture on the cool sides of the bomb. But this can not always be the nature of the combustion, judging from the sample of urine plus considerable cellulose. Here also the water was condensed on the sides of the bomb, and from the cellulose alone there should have been several calories HNO_3 dissolved in it, but the water was neutral. The ash, on the other hand, was decidedly alkaline. Where the urine was burned with but a small quantity of cellulose one-half of the bomb HNO_3 was found in the water. Here, too, the ash was alkaline. Nitric acid, it seems, can not be formed by the action of the flame and heat on nitrogen away from the ash or skeleton of the substance burned, but must be formed in the capsules holding the substance at the very point where the heat first attacks the compound, the place of greatest chemical activity. We can imagine that in a remarkably short time numberless chemical changes must take place at that point. The nitric acid does not leave this seat of action when there is some attraction strong enough to hold it. In the case of urine and other substances such an attraction seems to be in ash, and hence little or none of the nitric acid escapes with the other gases formed to the sides of the bomb. The attractions referred to can hardly be anything but the chemical affinity of the alkalies of the ash, which unite with the acids formed, thus holding at least part if not all of them. In this we have an explanation of how it is possible to have

less than the bomb HNO_3, since ash with alkaline reaction will prevent nitric acid from being dissolved in the water and perchance prevent in part its very formation.

Eight ashes left by the combustion of urine plus a little cellulose were analyzed for nitrogen, and the average of the results gave the equivalent of 1.1 calory HNO_3, which represents most of the 1.74 calories of missing nitric acid, as shown in Table X. Unfortunately, only these 8 ashes were saved for nitrogen determination. What the nitrogen compounds were in the ash was not determined, nor do we know anything about what part of the missing nitric acid was present in the ash, in the case of the urines, where all was missing, none being dissolved in the water in the bomb.

PROBABLE ERROR DUE TO DISAPPEARANCE OF NITRIC ACID.

Taking for granted that the plus values in the table refer to the total nitric acid formed, and that not any of it has united with anything else, the plus then does not mean an error, since all the nitric acid formed is measured and accounted for in the calculations. But the minus or missing nitric acid is in all probability always an error which would be greater or less than the values given in the last column, according to the nature of the combination formed. Thus errors are liable to be introduced when, in the operation of the bomb and computations of the results, the acidity in the solution titrated against NaOH solution is assumed to be HNO_3, and therefore the amount of heat represented by it always subtracted from the total heat generated in the bomb.

There are other acids formed in the bomb besides nitric acid, and directions for the manipulation of the bomb calorimeter should make specific mention of this fact and explain how they should be considered, so as not to introduce any error. They are not in any way equivalent to HNO_3, and should therefore not be treated as such. The writer has in mind especially the H_2SO_4.

It is generally accepted that in a complete combustion of a nitrogenous organic substance the nitrogen returns to free nitrogen and oxidizes only under extraordinary conditions such as may be produced by a powerful electric spark, or which exists in the bomb calorimeter where the combustion takes place in the presence of large excess of oxygen, etc. For this reason any heat caused by the formation of HNO_3 must be subtracted from the total heat generated in the bomb.

With sulphur compounds it is different. The natural combustion product of sulphur is the acid, and hence any heat produced by the formation of H_2SO_4 belongs to the compound and should not be subtracted. Especially is this true when the bomb results are to be compared with the combustions of organic substances as they take

place in the animal body. Part or all of the sulphuric acid may be held in the form of salts in the ash, but as the ash is practically an unexplored field, it will not be touched upon at all at this time.

Whether the H_2SO_4 is counted in as HNO_3 or not will at times make a great difference in the final results. This may be seen very clearly from some work which the writer did upon dandruff and hair (brushed off a steer at the daily cleaning), and pure hair, and upon two samples of steer urine.

The results so far as they bear upon this point are found in Table XII.

TABLE XII.—Difference in the heat values found when the total acidity is regarded as HNO_3 and when the H_2SO_4 has been subtracted.

Substance.	Charge.	Acid solution titrated against NaOH solution.			Calories per gram substance.		
		Total alkali.	Due to H_2SO_4.	Difference HNO_3.	Acidity called HNO_3.	Titration corrected for H_2SO_4.	Difference.
	Grams.	c. c.	c. c.	Calories.			Per cent.
Brushings (dandruff and hair),	1.0236	68.94	62.98	5.96	4,052.4	4,113.0	1.48
Do.	.8959	59.79	58.88	.91	4,048.7	4,125.7	1.87
Do.	.8809	59.62	58.27	1.35	4,066.6	4,132.7	1.60
Hair,	.9133	49.94	38.54	11.40	5,180.2	5,221.4	.79
Urine,	7.2462	1.60					
Do.	6.1216	1.65	1.1	3.97	153.36	153.42	.04
Do.	6.0444	1.82					
Do.	7.6021	2.92					
Do.	7.8134	3.19	3.1	6.37	175.6	175.73	.07
Do.	8.4447	3.36					

These few determinations will suffice to show that a very large error may be introduced by the H_2SO_4. In the case of urine the error introduced by reckoning sulphuric acid as nitric acid is small, but with the hair it reached about 0.8 per cent., and in the case of the epidermic tissue, dandruff, etc., which is richer in sulphur, the error was in one instance about 1.9 per cent.

CAUSE OF INCOMPLETE COMBUSTION.

The shape and size of crucible, or capsule, in which the substance is burned may influence the combustion.

Owing to inability to watch the process of the combustion in the bomb, the general opinion, gained perhaps from the observations of explosives, is that the combustion in the bomb calorimeter is very sudden and violent, in nature like an explosion in the free air. This, however, is not correct. The time of combustion varies with the nature of the substance, but, with the materials mentioned in the

previous tables, only by a very few seconds. It is of a very short duration but by no means an instantaneous flash. The supposed violence, implying that the flash fills the bomb, has absolutely no foundation and would not happen except when the oxygen contains a considerable percentage of highly combustible gases. To prove the correctness of this statement direct tests were made as follows: Small pieces of filter paper, about one-fourth inch square were fastened by one edge to the sides, top, and bottom of the bomb by means of paste, and allowed to dry. In one trial the burning of a small charge of cellulose did not affect the few pieces of filter paper which were fastened on the top and on the bottom of the bomb. After that a more complete test was made by fastening three pieces to the top, one at the center of the bottom, and ten distributed on the sides of the bomb; four of them about opposite the top of the capsule, four nearer the top, and two nearer the bottom. The charge was 1 gram powdered rock candy plus a little naphthalene, burned in 20 atmospheres oxygen. The test resulted in two of the three pieces on the top being burned, the third one showing in one corner a trace of brown as when paper has been held near strong heat. All the rest were absolutely untouched. Hence, the flames may at times reach the top, and perhaps more seldom the sides, though the distance is much shorter. With more oxygen the flame very likely would not even have reached the top of the bomb.

It is a known fact that fire will put itself out in a closed room, even before the oxygen is fully consumed. If this is true in a room, might it not also be true in a deep capsule surrounded by plenty of oxygen? To have some light shed upon this question, and to be able to decide in favor of some one of the different-shaped capsules used, the following tests were made: A wide-mouthed bottle of 1,500 c. c. capacity was filled with oxygen, and the crucible, attached to a wire fastened in the cork, was let down in the bottle, and the substance ignited by means of an iron fuse wire as in the case of the bomb combustion, and the burning watched. The substances burned were filter paper (cellulose), cut in disks and laid on the bottom of the crucible, and powdered sugar (rock candy). After combustion the ordinary test was made for the oxygen by means of a glowing splinter of wood. In all cases there was a large excess of oxygen, since the large cork could be removed and the splinter plunged in and ignited several times in succession.

In the following table, which gives the results of the tests, crucible No. 1 was a large nickel crucible, one and five-eighth inches in diameter at the top and one and seven-sixteenth inches deep. Crucible No. 2 was a small nickel crucible, seven-eighth inch in diameter by eleven-sixteenth-inch deep. Crucible No. 3 was the same as No. 2, perforated, and crucible No. 4 was the same as No. 3 with the holes enlarged. A small piece of cellulose, not weighed,

was put under the sugar in the crucible in one case to facilitate the combustion. The time which the substance stood in the bottle before ignition was noted, as well as the length of time it continued to burn. The last column in the following table gives the unburned residue:

TABLE XIII.—Powdered sugar and cellulose burned in different-shaped crucibles in oxygen under atmospheric pressure.

Substance.	Crucible.	Weight of substance.	Time before ignition.	Time of combustion.	Unburned residue.
		Gram.	Minutes.	Seconds.	Grams.
Cellulose,	1	0.2190	30	60	0.0000
Sugar,	1	.2675	5	75	.0077
Do.	2	.2454	5	180	.0081
Cellulose,	2	.1890	5	165	.0026
Sugar,	3	.2582	8	195	.0122
Do.	4	.2132	90	75	.1609
Sugar and cellulose,	4	.2037	5	60	.0060
Cellulose,	4	.1585	15	40	.0002

In only one instance did the substance burn without leaving any unburned residue of carbon. There was a marked difference between the two substances in the way they burned, the sugar taking longer time and leaving a great deal of unburned matter. A number of holes were made near the bottom of the small crucible. During the burning some of the holes became coated over with a film of charred material, the flame remained smaller, and the circulation of the gasses, i. e., of oxygen, to the burning substance was lessened. When the holes were enlarged these last-mentioned hindrances were magnified and the sugar burned only in part, most of it was left untouched by the small flame, and in one spot it was not even fully melted. It is possible that in this case some of the oxygen might have leaked out on standing, but after the combustion there was enough left in the bottle to allow the glowing splinter to burst into flame several times. When the sugar rested on a small piece of filter paper the combustion of the sugar was more nearly complete, and filter paper alone was practically completely burned in crucible No. 4.

The figures of the table, as well as the actual behavior of the combustion, indicate the shape of the larger crucible, which was very much broader at the top than at the bottom, as being the best. The combustion itself, or we may say the supply of oxygen to the burning points, was more uniform with the larger and more intermittent with the smaller crucible. A good start, and much heat quickly generated, are factors which undoubtedly contribute much to make a com-

bustion complete, but these may not in the least change the conclusion reached as to the shape of the crucible or capsule best suited for the work.

ALCOHOL HEAT VALUE.

Time did not permit me to take up the question of alcohol heat value as fully as I desired, hence at this time I shall make mention of only a few points which have come up in connection with the determination of heat of combustion, and make some suggestions which may at least be of practical value.

Alcohol being a volatile liquid it can not be satisfactorily burned in an open dish, but must be enclosed in a receptacle from which it can not evaporate, and gelatin capsules of known heat value are generally used for this purpose. The alcohol charge should never be weighed out by difference—i. e., by weighing the bottle—but the actual amount placed in the capsule should be weighed. The reason for this is to make sure that there is no evaporation. Unless the capsule with the alcohol is weighed a little evaporation may not be noticed, and if the capsule is not tight enough to hold the alcohol while it is being weighed it is not fit for the work. A little evaporation of alcohol from the capsule in the bomb will always cause the results to come too low, since alcohol vapors are not fully burned. To insure complete combustion of the alcohol and the gelatin the capsule may be filled with clean, ignited asbestos to absorb the alcohol.

Another way to obtain good combustions of the alcohol and gelatin, though not so simple as the gelatin-capsule method, is to make use of a tubular platinum capsule, about one-fourth of an inch in diameter, having perforated sides and bottom. This platinum capsule is coated with a mixture of the best gelatin with about 10 per cent. of glycerin and water, all gently heated. The coating is allowed to dry, and the weight of the gelatin mixture is ascertained. Separate portions of the mixture are dried and analyzed for the heat value. This gelatin-coated capsule can be used with or without asbestos. Caps can be made of the same material to fit tightly over the end, or inverted, used as plugs. It requires less gelatin to coat such a capsule and make it alcohol tight than is found in the ordinary gelatin capsules used.

The weight of all gelatin capsules, etc., should be taken when the material is dry, and this weight should be used in correcting for the heat of combustion of gelatin. But before using they should have been exposed to room conditions for a considerable time, else there is no constancy about them when they have to be reweighed and filled with alcohol.

ALCOHOL DETERMINATION USED FOR TESTING THE RESPIRATION CALORIMETER.

This was absolute alcohol diluted with distilled watr, and hence the first step was to obtain its specific gravity. Two pycnometers were used and the specific gravity was taken at 15.6° C., as follows:

	No. 1.	No. 2.
	Grams.	Grams.
Pycnometer, plus distilled water,	77.2663	87.2591
Pycnometer, empty,	27.2385	37.2259
	50.0278	50.0332
50 cc. air,	.05894	.05894
Water,	50.08674	50.09214
Pycnometer, plus alcohol,	68.4121	78.4056
Pycnometer, empty,	27.2385	37.2259
	41.1736	41.1797
50 cc. air,	.05894	.05894
Alcohol,	41.23254	41.23864

No. 1. 41.23254÷50.08674=.823222 specific gravity.
No. 2. 41.23864÷50.09214=.823255 specific gravity.
Average, =.823238 specific gravity.
According to Squibb, at 15.6° C.
0.82755 specific gravity=88.0 per cent. pure alcohol.
.81684 specific gravity=92.0 per cent. pure alcohol.

Difference, .01071 specific gravity= 4.0 per cent. pure alcohol.
0.82755 =88.0 per cent. alcohol.
.823238= unknown alcohol.

.004312
0.01071 : 0.004312 :: 4.0 : X X=1.6105 per cent.
Hence 88.0+1.6105=89.611 per cent. ethyl alcohol.

DETERMINATION OF HEAT OF COMBUSTION.

Using the old water value of the bomb and without any correction for oxygen, two determinations of the capsule gelatin gave an average of 4,871 calories per gram, and the average of three determinations of the alcohol gave 6,458.7 calories per gram, or 7,207 calories per gram pure alcohol. Applying the correction found for impurities in oxygen by burning 1 gram cellulose, and using the corresponding water value of the bomb, the average for the gelatin was 4,860 calories per gram, and for the alcohol 6,447 calories per gram, or 7,194 calories per gram pure alcohol.

A sudden jar of the bomb caused one capsule containing alcohol to fall to the bottom of the bomb. It was ignited, and the determination was carried through as usual, but only 6,949.8 calories per gram pure alcohol was measured—that is, 3.4 per cent. less than the above average. Upon opening the bomb there was found a black spot and

some yellowish oily liquid at the bottom, and a strong, very peculiar odor mixed with odor of alcohol was noticed, thus showing incomplete combustion very decidedly. Another charge of alcohol which had remained in the capsule in the bomb for several hours before ignition gave 7,091 calories per gram pure alcohol. Here, where there was opportunity for evaporation, the heat obtained was less than the average of the three other determinations.

These observations are sufficient to show that to obtain correct values great care must be taken when volatile substances are to be burned in the bomb.

One or two questions which may possibly prove to be of some importance in connection with this work will be considered briefly.

These questions concern the contents of the bomb before and after combustion, and their influence upon the measurement of the heat, namely, the influence which the changes in the contents have upon the water value of the bomb, and the quantity of heat held by these various compounds formed and not accounted for.

In the following calculations I shall use the values for specific heats, etc., as given below:

Per unit weight:
Cane sugar=0.301 specific heat.
Water =1.000 specific heat.
O_2 = .2175 specific heat.
CO_2 = .1875 specific heat.
O_2 1 liter =1.4298 gram.

To illustrate these problems and for the sake of simplicity we shall consider one example, leaving out all of the minor things which would complicate the calculations. Thus, we have a bomb of 360 c. c. capacity. In the bomb, before combustion, are 1 gram cane sugar and 20 atmospheres pure oxygen, all at 20° C. What changes take place when the sugar is burned, and what are their significance?

According to the weight and specific heat of the substances in the bomb, they represent a certain mass of water at the same temperature; also, a definite quantity of heat is held by them, which may be expressed in calories. Twenty atmospheres oxygen would then be—

360 c. c.=7,200 c. c. oxygen.
7,200×1,4298 (weight of 1 liter oxygen)=10,29456 grams oxygen.
10.29456×0.2175 (specific heat)=2.239 grams water.
1 gram cane sugar×0.301 specific heat=0.301 gram water.

Hence the substances in the bomb represent—

Oxygen	2.239 grams H_2O
Sugar	.301 grams H_2O
Total	2.540 grams H_2O

The sugar burns to CO_2 and H_2O, and after the combustion of 1 gram sugar we find 0.5793 gram water and 1.5426 gram CO_2.

1.5426 grams $CO_2 \times 0.1870$ specific heat=0.288 gram water.
10.29456—1.1219=9.1727 grams O_2, and $\times 0.2175$=1.933 grams water.

Thus in the bomb after combustion we have—

Oxygen equivalent to	1.933 grams H_2O
Carbon dioxide equivalent to	.288 gram H_2O
Water	.5973 gram H_2O
Total	2.8003 grams H_2O
After combustion	2.8003 grams water
Before combustion	2.5400 grams water
Difference (increase)	.2603 gram water

The whole bomb system therefore has changed to an extent equivalent to 4.2603 gram water during the combustion. This is equal to 0.011 per cent. of the total bomb water value plus water used, or an error of about one-half calory in the ordinary determination. If, for instance, 1 gram butyl alcohol should be burned instead of sugar, the change in the system would be equal to 0.4685 gram water—an error of 0.019 per cent.

This is a very small error, and, at the present, is perhaps altogether negligible.

The next question is, To what extent does this change of contents affect the heat evolved during the combustion?

This question refers to the same changes in the contents of the bomb as did the preceding one, but instead of studying their effect upon the water value of the bomb we want to see what the effect will be upon the determination of heat of combustion when the factor for the bomb and the water used remains the same.

In the case of the sugar there was an increase of 0.2603 gram water in the bomb, which, raised to 1.7° C., would equal about one-half calory held by it. The correction will, in other words, in the case of sugar, be the same whichever way we apply it, but this is not necessarily true of all substances burned. As said before, the correction is so small that it need seldom be considered.

CONCLUSION.

From what has been said, then, we learn that there are many possibilities for error in the work with the bomb calorimeter. Undoubtedly many investigators in the past have worked with impure oxygen and never questioned its purity. In the light of our present experience it is questionable whether Stohmann himself, by the use of a heated copper tube, could have removed the last traces of combustible gases from his oxygen.

The disappearance of nitric acid formed and its relation to the ash has not been taken into consideration, and it is only within a couple of years that the thermometer lag has come to be applied in the calculations of the results.

These overlooked or at times unknown difficulties, which have been referred to throughout this paper, may be the cause of some of the disagreements of results as experienced by different investigators and referred to in the earlier part of this paper.

From what has been done and said I believe we also have learned that much work is yet needed in the different lines indicated before the method for determinations of heat of combustion by means of the bomb calorimeter can be called perfect.

DIVISION OF HORTICULTURE.

GEORGE C. BUTZ, M. S., Horticulturist.
J. PLUMMER PILLSBURY, Assistant in Horticulture.

REPORT OF THE HORTICULTURIST.

To the Director:

Sir: I have the honor to report upon the work of the Division of Horticulture for the past fiscal year as follows:

At your suggestion and with your counsel in devising a test of commercial nitroculture bacteria, an experiment was begun in February of 1905, and continued to the close of that year and the report has been prepared for publication. Through several farmers of the State, a number of samples of nitroculture bacteria were obtained from the National Nitroculture Company of West Chester, Pa. This course was adopted to secure samples that would fairly represent the quality of the article furnished to the trade. These samples were used to inoculate certain leguminous seeds according to directions furnished with the samples. Pot cultures were made in the College greenhouses, using sterilized sand as the soil medium. This was followed by a field test of the inoculated seeds, and in both instances the use of the nitroculture material showed practically no gain either in the production of nodules upon the roots of the legumes or in the growth of the plants. The results of this experiment should discourage the use of nitroculture bacteria distributed upon cotton, but should not be interpreted to weigh against the well established fact that the proper active bacteria in the soil of a leguminous crop aid the plants greatly to secure nitrogen from the atmosphere.

The work done by this Division among the grape growers of Erie county in 1903 was so satisfactory and successful that it induced many of the vineyardists in that section to follow the course then recommended to protect the grapes against the invasions of fungous diseases. Early in 1905, the Horticulturist visited the same region to determine if any further demonstration work would be helpful to the grape growers and was assured by the leading growers that nothing more was called for as the practice of spraying intelligently followed gave excellent results. In February, 1906, the Bureau of Plant Industry of the U. S. Department of Agriculture requested this Station through its Division of Horticulture to cooperate in further work on the control of black rot and other fungous diseases in the grape section of Erie county. Such co operation was approved and accordingly the Horticulturist in company with Mr. C. L. Shear of the Bureau of Plant Industry visited the grape growers of the vicinity of North East, Pa., on May 4, 1906, to enlist the co-operation of the growers. Several vineyardists agreed

to devote portions of their vineyards to this work, which will be carried on chiefly under the care of an agent of the United States Department of Agriculture.

A considerable industry in celery culture having developed within recent years in the vicinity of Wellsboro, Tioga county, Pa., on muck land well suited to this special crop has reached a point where the fungous diseases of the celery are causing alarm among the growers. At the request of the local grange of Wellsboro and with the approval of the Director, the Horticulturist met in conference with these celery growers on April 26, 1906, and inaugurated a course of treatment to be followed during the present season for the control of blights.

Since March, 1905, this Station has invited the farmers of the State to send samples of agricultural seeds which they contemplate buying or using in order to have them tested for vitality and purity and to have identified the weed seeds which may be found to contaminate the samples. No charge is made for this service to the farmers of Pennsylvania and the work was assigned to the Division of Horticulture. This proposition was advertised over the State at the Farmers' Institutes, and up to this time forty samples of seeds have been received and reported upon. The information given has been gratefully received and it is likely that as the advantages become known this work will greatly increase. It requires not only the close attention to the germinator but also considerable technical skill in identifying the foreign seeds of the samples.

The experiment which has been in progress for several years to determine what if any is the effect of the use of whole or piece roots as stocks for apples is still continued, and up to this time no effect has been discovered that is worthy of publication. The trees have not yet reached a bearing age.

The Horticulturist devoted six weeks of continuous work in December and January of the past year lecturing at Farmers' Institutes in the State of Pennsylvania, and in the month of August assisted in the official inspection of nurseries at the request of the Secretary of Agriculture of the State.

Respectfully submitted,

GEORGE C. BUTZ,
Horticulturist.

A TEST OF COMMERCIAL CULTURES FOR LEGUMES.

BY GEORGE C. BUTZ.

SUMMARY.

A test of the value of commercial cultures sold in the United States in 1905 for the purpose of insuring the development of nodules on the roots of legumes was made in pot cultures and in field plots during the year.

The cultures were disseminated on dry absorbent cotton, and were

purchased by farmers from the National Nitro-Culture Company, West Chester, Pa.

The cultures obtained were specifically intended for alfalfa, soy bean, vetch and cowpea, and were used to inoculate seeds of these legumes according to the printed directions accompanying the purchases.

The seeds in pot cultures germinated uniformly whether inoculated or not. The plants grew about equally well, and the examination of the roots at the conclusion of the test revealed the fact that there was no real gain in the use of the cultures as there were as many nodules upon plants without inoculation as upon those inoculated.

The test by field cultures virtually corroborated the results of the pot cultures.

No gain was observable in the growth of the plants in the field and the number of nodules upon the roots was not apparently affected by inoculation.

The soy bean in pot cultures developed no nodules in any case, while in field cultures it bore the largest number of nodules of any legumes planted both with and without inoculation .

The cultures being ineffective, the test of the specific value of a culture for a particular legume affords no data for observation on that point.

The beneficial effects of growing leguminous crops upon farm land by increasing the fertility of the soil has been known to scientists and farmers for many years, but a scientific explanation of the fact was not made until in 1886 when Helriegel at a meeting of scientists in Berlin asserted that legumes unquestionably obtained nitrogen from the atmosphere and thereby increased the nitrogen supply in the soil. This discovery was supplemented two years later when, with Wilfarth, he demonstrated that the nodules upon the roots of legumes were essential agents in helping the plants to obtain nitrogen from the air. These nodules had been observed by botanists and other writers upon plant life and various opinions were expressed as to their cause, nature and functions, but the first to discover bacterial life in these swellings was Woronin who in 1866 advanced the theory that the minute organisms he found were the cause of the nodules. Subsequently the investigations of Lawes and Gilbert in England, Atwater and Woods in America and many others have verified the observations made by Helriegel, Wilfarth and Woronin. Atwater and Woods were the first to demonstrate by sand cultures of vetch that these plants will thrive in a nitrogen-free medium if inoculated with the nodule-forming bacteria, but will die early if not inoculated, thus proving the direct effect of these bacteria in the soil.

These bacteria are single-celled organisms somewhat closely allied to the "yeast plant." They gain entrance to the roots of legumes through the root-hairs and under favorable conditions multiply very rapidly causing the formation of the characteristic nodules. It is here that the bacteria exercise their power of taking the nitrogen of the soil air and combining it with other elements form their own tissues. As these bacteria die with almost the same rapidity that they originate the host plant dissolves and absorbs the combined nitrogen of the organisms and thus profits by the presence of bacteria in its roots.

A study of soil conditions reveals the fact that these nodule-forming bacteria are present in most soils so that the ordinary sowing of seeds of legumes may result in a good crop with an abundance of nodules. Nevertheless, there are some soils in which the important bacteria are deficient or perhaps entirely wanting, and in such cases the nodules will form sparingly or not at all. If the soil is well supplied with nitrogen a good growth may be made even in the absence of nodules, but the growing of the legumes would not enrich the soil any more than would a crop of corn or oats.

To introduce the proper bacteria into soils when the nodules do not form, a practice has sprung up both in Europe and in this country of transferring soil from a field producing nodules abundantly and scattering it over the land to be inoculated at the rate of a bushel to an acre. But this practice is not always attended with success. The objections raised against this method of inoculation have been that it is laborious and expensive to handle such a large quantity of material and that obnoxious weed seeds and plant diseases are introduced into new fields.

To overcome these objections Professor Knobbe, of Tharandt, Germany, prepared pure cultures of the bacteria and transferred them to tubes or bottles of a nutrient jelly. These cultures were called "Nitragin," and were distributed in Europe and America. The results obtained by the use of Nitragin were not always favorable; in this country particularly they were more commonly unfavorable. This preparation is no longer manufactured.

In 1904, Dr. George T. Moore,* in charge of the Laboratory of Plant Physiology of the U. S. Department of Agriculture devised a method of distributing the specific bacteria in a dry state upon absorbent cotton. The method was tested by distributing material free of charge to many farmers throughout the United States, and many favorable reports obtained in this way were published. In the Century Magazine of October, 1904, a popular article prepared by G. H. Grosvenor exploiting the "new discovery" of Dr. George T. Moore aroused a wide spread interest in the "vest pocket fertilizer."

About this time, the National Nitro-Culture Company, of West Chester, Pa., began advertising and selling cultures of bacteria prepared according to Dr. Moore's method charging $2.00 for a quantity sufficient to inoculate seed for one acre of land.

The New York Agricultural Experiment Station at Geneva in the Spring of 1905† made a bacteriological study of these commercial cultures and found that they were "worthless for practical purposes" and condemned not the principle of inoculation, but the method of distributing the bacteria upon dry cotton.‡

The tests of cultures from the same firm now reported in this bulletin further condemns the use of this method for distributing bacteria.

Many inquiries coming to this Station for an opinion as to the merits of the article offered for sale by the National Nitro-Culture Company of West Chester, Pa., made it seem desirable to give the material a trial. In February 1905 a number of packages of nitro culture bacteria were purchased from the National Nitro-Culture Company in West Chester, Pa., not directly but through several

*Bul. 71, Bureau of Plant Industry, U. S. Dept. of Agr., 1905.
†Bul. 270, N. Y. Agr. Expt. Station, Geneva, 1905.
‡A. F. Wood, The Pathologist of the U. S. Dept. of Agr., claims that the New York Station dried its cultures too slowly in their work.

farmers of the State. In this manner cultures were obtained for inoculating seed of alfalfa, vetch, soy bean and cowpea.

Plan of the Experiment.

Seeds of the four leguminous crops just mentioned were obtained for the purpose of inoculating a portion of each kind so that both inoculated and non-inoculated seed could be planted in six-inch flower pots filled with sterilized sand, to which might be added a sufficien quantity of mineral plant food. These pots were kept in a greenhouse where an average temperature of 65 degrees F. was maintained.

The sand was washed free from soluble materials and heated to thoroughly sterilize and burn out the organic matter in order to secure a nitrogen free medium.

The seed was inoculated strictly in accordance with the directions furnished with the bacteria, of which the following is a copy:

"NATIONAL NITRO-CULTURE CO.

DIRECTIONS FOR USING NITRO-CULTURE.

The package accompanying this direction sheet will keep for one year from date, if it is not wet or overheated. Consequently keep in a cool dry place and do not open it until ready to prepare the culture, which should be three or four days before planting.

TO PREPARE SOLUTION.

Procure a jar or bottle that can be scalded out thoroughly. After cooling, fill with quantity of clean water named on package A and add the contents of package A and B. Cover the jar and set away in a warm, shady place, avoiding a heat greater than 100 degrees F. At the end of 24 hours add the contents of package C and allow to stand until the water turns cloudy. This will usually take place in from 24 to 36 hours, depending upon the temperature. If the water has been kept very cold it will require longer to become milky.

TO INOCULATE SEED.

With the cloudy solution prepared according to the above directions, thoroughly moisten the seed to be planted. Do not soak them. As soon as all the seed have been in contact with the solution, spread them out in a shady place to dry. When dry the seed can either be planted at once or kept on hand for several weeks without damage, provided they are kept dry and out of the sun.

To any of the solution that may remain add one gallon of water and mix with sand or earth. This inoculated earth may then be spread over the field and harrowed in, adding an extra quantity of Nitro-Culture to the soil."

After planting the seeds in the pots of sand, the pots were watered until saturated, using about 325 c. c. of tap water, to which was added 10 c. c. of liquid plant food prepared by Dr. Wm. Frear, the Chemist of the Station. The 10 c. c. of liquid plant food contained .06 grams of water-soluble $P_2 O_5$ corresponding to .10 grams of Ca H P O_4 G and .076 grams of $K_2 O$, equivalent to .10 grams of K Cl.

As the plants during growth showed signs of needing more of this plant food, 2 c. c. of the prepared solution were added to 100 c. c. of tap-water and used in watering the pots.

Cross inoculations were made to test the merits of the claim that specific germs had special value with particular legumes; that is, bacteria labeled for alfalfa were used to inoculate seeds of vetch and vice versa.

Seeds of both the inoculated and non-inoculated portions were also planted in pots of a good greenhouse soil for a comparison of results.

After the season opened for outdoor work a field test of all the inoculated and non-inoculated seeds was made. In this experiment, as in the pot experiment, the principle object was not to compare the yields of each crop, but rather to test the presence or activity of the bacteria by the production of nodules upon the roots of the legumes.

The "nutritive salts" sent out by the National Nitro-Culture Company with the bacteria were submitted to the Station Chemist for a qualitative analysis and he reported as follows:

"The package marked A yields about 11 per cent. of ash. The ash is chiefly composed of magnesium phosphate with potash, lime and a little sulphuric acid. The two bases last named are properly present as phosphate and sulphate respectively. Packet C appears to be composed almost entirely of ammonium phosphate, though it exhibits traces of sodium."

The series of pots in this experiment were prepared as follows:

Pot No. 1. Sand, planted to alfalfa inoculated with alfalfa bacteria.

Pot. No. 2. Sand, planted to alfalfa inoculated with alfalfa bacteria (a duplicate of Pot No. 1).

Pot No. 3. Sand, planted to soy bean inoculated with soy bean bacteria.

Pot No. 4. Sand, planted to soy bean inoculated with soy bean bacteria (a duplicate of Pot No. 3).

Pot No. 5. Sand, planted to vetch inoculated with vetch bacteria.

Pot No. 6. Sand, planted to vetch inoculated with vetch bacteria (a duplicate of Pot No. 5).

Pot No. 7. Sand, planted to cowpea inoculated with cowpea bac-

Pot No. 8. Sand, planted to alfalfa not inoculated.

Pot No. 9. Sand, planted to soy bean not inoculated.

Pot No. 10. Sand, planted to vetch not inoculated.

Pot No. 11. Sand, planted to cowpea not inoculated.

Pot. No. 12. Sand, planted to alfalfa inoculated with vetch bac-

Pot No. 13. Sand, planted to soy bean inoculated with alfalfa bacteria.

Pot No. 14. Sand, planted to vetch inoculated with cowpea bacteria.

Pot No. 15. Sand, planted to cowpea inoculated with soy bean bacteria.

Pot No. 16. Soil, planted to alfalfa inoculated with alfalfa bacteria.

Pot No. 17. Soil, planted to soy bean inoculated with soy bean bacteria.

Pot No. 18. Soil, planted to vetch inoculated with vetch bacteria.
Pot No. 19. Soil, planted to cowpea inoculated with cowpea bacteria.
Pot No. 20. Sand, planted to alfalfa inoculated with alfalfa bacteria.
Pot No. 21. Sand, planted to soy bean inoculated with soy bean bacteria.
Pot No. 22. Sand, planted to vetch inoculated with vetch bacteria.
Pot No. 23. Sand, planted to cowpea inoculated with cowpea bacteria.
Pot No. 24. Sand, planted to vetch inoculated with alfalfa bacteria.
Pot No. 25. Soil, planted to alfalfa not inoculated.
Pot No. 26. Soil, planted to soy bean not inoculated.
Pot No. 27. Soil, planted to vetch not inoculated.
Pot No. 28. Soil, planted to cowpea not inoculated.

CHRONOLOGICAL NOTES ON THE POT CULTURES.

Feb. 25. Seven quart jars were sterilized with boiling water and were then filled with tap-water (hydrant water) to receive the samples of nitro-culture. There were two samples for alfalfa, two for soy bean, two for vetch and one for cowpea. Directions for the last named called for a two quart jar, but only one-half quantities were used as this would afford ample material. Packages labeled A and B of the directions were dissolved in the water to stand 24 hours.

Feb. 26. Packages labeled "C" were added to the jars and kept in the laboratory at a temperature of 70 degrees F.

Feb. 27. No cloudiness appeared in any of the jars after 24 hours.

Feb. 28. After 48 hours the anticipated cloudiness which was an indication of the multiplication of bacteria was very marked in two of the jars, and was beginning in the remaining five jars.

March 1. All the solutions were very cloudy now, and the seeds provided for the experiment were inoculated by moistening them with the "cultures" and drying them off previous to planting them in the pots of sand and of soil, which was done on this day.

March 2. The pots were watered with tap-water.

March 3. Pots Nos. 25, 26, 27 and 28 with greenhouse soil were planted with seeds of alfalfa, soy bean, vetch and cowpea respectively without inoculation. These seeds were two days late in getting into the soil.

March 4. The seeds in pots Nos. 1, 2, 8, 12, 16 and 20 had all vegetated (all alfalfa seeds) evenly and uniformly. Showing no effect of inoculation on germination of the seed. The plantlets were thinned out, leaving but 12 plants in each pot. All plants looked equally well. The pots were placed on benches in the greenhouse in full light.

March 6. All remaining seeds had vegetated uniformly and evenly. The plants were thinned out leaving 18 plants of vetches and six plants each of soy bean and cowpea to a pot. The pots were then placed on the bench of the greenhouse beside the alfalfa pots. The

pots rested on sifted soft coal ashes which was used to cover the green house benches.

March 20. The pots of sand which had received no nitrogen were watered with 2 c. c. of the prepared solution of plant food containing phosphoric acid and potash because the plants began to lose in healthy color.

March 27. Twenty-five c. c. of lime water was given to each pot of sand to prevent acidity in the medium, though such a condition could not be discovered by a litmus paper test.

April 6. The pots of sand were again watered with 25 c. c. of lime water as on March 27.

May 10. Plants of all kinds growing in sand water whether inoculated or not showed strong signs of maturing their growth and turning yellow in foliage. A supply of nitrate of soda was given to pots Nos. 1, 3 and 5 of which there were exact duplicates in pots Nos. 2, 4 and 6 to reinvigorate the plants if possible. Later results showed no appreciable gain from this last treatment.

June 1. Many of the plants in the sand culture had reached a point in their development where it was evident that the loss of falling leaves was becoming more rapid than the gain in growth, and the great majority of them had reached their maximum development, that it was decided to terminate the pot experiment to take records of growth by measuring the height of plants, count the nodules on the roots and take the weight of the air-dry material of tops and roots. All kinds of plants reached a flowering stage in their development and many of them ripened seed pods with good seeds.

The plants were now removed from the sand and soil by lowering the pots in a tub of water. The sand and soil dropped from the inverted pots, leaving the root systems unbroken and all the nodules were thus preserved upon the roots. In many cases the growth of plants was so strong that the roots penetrated the coal ashes on the benches; the ashes being loose, the roots were all obtainable.

ALFALFA.

Pot.	Medium.	Inoculation.	Number of plants.	Height of stem. Inches.	Number of leaves.	Weight of top. Grams.	Weight of roots. Grams.	Number of nodules.
1	Sand, ...	With alfalfa, ...	12	2- 5	6-10	0.5	0.75	9
2	Sand, ...	With alfalfa, ...	12	3- 6	6.12	0.35	0.57	9
3	Sand, ...	Nothing, ...	12	2- 5	6-10	0.15	0.30	8
12	Sand, ...	With vetch, ...	12	15- 2	3- 6	0.12	0.30	0
16	Soil, ...	With alfalfa, ...	11	12-23	.....	19.00	14.50	333
25	Soil, ...	Nothing;	10	12-19	.....	13.50	12.00	356
20	Sand, ...	With alfalfa, ...	12	15-24	4- 7	0.16	0.16	1

Pots 1 and 2 are duplicates except that the inoculation was made from two different packages of bacteria. The plants were all single stemmed, that is there was no tendency to stooling or branching from the base. The roots in both pots weighed more than the tops. In No. 1 they extended three inches from the bottom of the pot, but in No. 2 they were all within the pot. Pot No. 8 was planted with

seed without inoculation but in other respects was like 1 and 2. It will be seen that the plants were about the same size but weighed considerably less when air-dried. In all these three cases, the nodules ranged in size from that of white clover seed to sweet pea seed. Pot No. 12 developed the weakest plants. The seeds were inoculated with bacteria intended for vetch, and no nodules whatever could be found. Pots 16 and 17 were alike except that the former was inoculated and the latter was not. In the greenhouse soil the plants made a larger and heavier growth than in sand. They branched much at the base and developed thick taproots. They would have grown much larger if the experiment had not been discontinued. The roots extended fifteen inches into the coal ashes of the bench. The nodules were very abundant on the roots of both pots and so nearly equal that no advantage could be claimed for the inoculation. The difference, however, was in favor of plants without inoculation.

In this experiment with the alfalfa it is clearly shown that there was no decided advantage in the use of the "Nitro-Culture." Pot No. 20 has no real place in this experiment. The inoculated seed was planted in the sterilized sand and no plant food whatever, except such as might be obtained from the hydrant water, was afforded the plants.

SOY BEAN.

Pot.	Medium.	Inoculation.	Number of plants.	Heighth of stem. inches.	Number of leaves.	Weight of top. Grams.	Weight of roots. Grams.	Number of nodules.
3	Sand, ...	With soy bean, ...	6	6- 7	.....	3.70	1.60	0
4	Sand, ...	With soy bean, ...	6	4- 6	.....	3.80	1.65	0
9	Sand, ...	Nothing, ...	6	6- 8	.....	3.30	2.25	0
13	Sand, ...	With alfalfa, ...	6	6- 8	.....	3.60	1.85	0
17	Soil, ...	With soy bean, ...	1	12	.....	7.60	4.00	0
26	Soil, ...	Nothing, ...	1	12	.....	6.55	3.45	0
21	Sand, ...	With soy bean, ...	4	6- 8	.....	2.40	1.12	0

Pots 3 and 4 are alike in all respects except that the inoculation was made from two different packets, hence they may be regarded as duplicates, and the record shows that they developed very uniformly. Several plants in each pot matured one or two pods with a good seed in each. The roots developed abundantly, extending several inches from the bottom of the flower pots. It is remarkable that no nodules were discovered upon any roots of all the soy beans in this experiment. It might be said here, however, that in the field test referred to later in this discussion there were many large tubercles found on all the soy bean plants.

Pot No. 9 may be compared directly with pots 3 and 4 to study the effects of inoculation. Without inoculation the plants were equally large, the root development nearly a third greater, the flowering, setting of pods and maturing seeds was equally strong.

Pot No. 13 was planted with seed inoculated with alfalfa bacteria. The plants developed uniformly with all the preceding soy

beans. Another comparison is afforded by the plants in soil, pot 17 being inoculated and pot 26 not inoculated. In both these cases only one plant developed as the seeds rotted very generally during germination. The remarkable difference in the size of these plants when compared with those in sand is only appreciated when we multiply the weights of the soil plants by six to correspond with the six plants in the sand pots. The plants in soil extended several inches into the coal ashes of the bench, but nowhere upon the roots could nodules be found.

We are forced to conclude from this experiment with soy beans that there was no marked advantage in the use of "nitro-culture," either in the sand test or the greenhouse soil test.

Pot No. 21 like pot 20 of alfalfa is included here only to show the development made by the plants growing in sterilized sand without any plant food except what could be obtained from the hydrant water.

VETCH.

Pot.	Medium.	Inoculation.	Number of plants.	Height of stem. Inches.	Number of leaves.	Weight of top. Grams.	Weight of roots. Grams.	Number of nodules.
5	Sand, ...	With vetch, ...	18	5-13	.....	1.00	5.15	2
6	Sand, ...	With vetch, ...	12	10-24	.....	2.10	5.20	150
10	Sand, ...	Nothing, ...	9	6-14	.....	0.40	4.60	2
14	Sand, ...	With cow pea, ...	18	12-33	.....	8.00	5.65	84
24	Sand, ...	With alfalfa, ...	18	8-19	.....	1.05	3.95	0
18	Soil, ...	With vetch, ...	14	36-60	.....	25.00	7.00	960
27	Soil, ...	Nothing, ...	16	24-48	.....	15.50	4.00	732
22	Sand, ...	With vetch, ...	12	8-14	.....	0.75	1.75	2

Pots 5 and 6 are exact duplicates, except that the seeds were inoculated from duplicated packets of the "nitro-culture" for vetch. Unlike the duplicates of alfalfa and soy bean we find here a marked difference in results. In comparing the figures of the table above, it should be observed that only 12 plants developed in pot 6 whereas 18 plants developed in pot 5. The smaller number was occasioned by accidents to the young seedlings soon after thinning to the uniform number of 18.

The plants in pot 5 were slender and frail. They never flowered and some of them were dead several days before the discontinuance of the experiment, and the others had stopped growing. The roots were abundant at the top of the pots but some few extended from the bottom of the pots about four inches. The nodules, two in number, were small, only about the size of red clover seed.

Pot 6 had plants which grew twice as long as those of pot 5. These plants however did not blossom, and several had died a few days previous to the discontinuance of the experiment. The roots were not much more abundant. They projected from the bottom of the pot about six inches. The nodules 150 in number were uniformly about the size of red clover seed, although there were several clusters about certain points on the roots.

The only explanation that could account for this abundance of nodules is that the "nitro-culture" bacteria were effectual in this

instance and not with pot No. 5. Pot 10 was not inoculated, and yet the plants excelled those of pot 5. The roots of nine plants were almost as abundant as those of 18 plants and two nodules the size of white clover seed were found on the roots of pot 10. Pots 14 and 24 are interesting here, because in the former the vetch seed was inoculated with cow pea bacteria and in the latter was inoculated with alfalfa bacteria. The plants in pot 14 were green and vigorous when taken from the pot, and would have grown much larger if allowed to remain. A considerable development of roots was found in the coal ashes of the bench, and more than half of the nodules were on this portion of the roots. The plants in pot 24 were weak and dying when taken from the pot and no nodules were found.

Pots 18 and 27 afford a comparison of plants with and without inoculation under uniform treatment in greenhouse soil. The plants grew with great vigor and flowered freely. All the vetches had wire trellises to climb over, but in those two cases they proved to be too small to properly accommodate the plants. The roots extended 10-12 inches into the ashes of the bench. The nodules almost equally numerous in both cases were single and in clusters, ranging in size from white clover seed to clusters as large as kidney beans.

Here again we have no strong evidence in favor of the use of the "nitro-culture" on absorbent cotton, with the possible exception of pot No. 6.

Pot No. 22 is a case of inoculated seed in sterilized sand without any plant food, except what could be obtained from the hydrant water used to water the plants daily.

COW PEA.

Pot.	Medium.	Inoculation.	Number of plants.	Heighth of stem. Inches.	Number of leaves.	Weight of top. Grams.	Weight of roots. Grams.	Number of nodules.
7	Sand, ...	With cow pea, ...	6	5- 8	.....	1.60	1.75	3
11	Sand, ...	Nothing, ...	6	6- 8	.....	1.35	2.15	1
15	Sand, ...	With soy bean, ...	6	6-10	.....	2.50	2.85	10
19	Soil, ...	With cow pea, ...	5	10-14	.....	8.00	4.55	32
28	Soil, ...	Nothing, ...	5	10-14	.....	6.55	4.85	28
23	Sand, ...	With cow pea, ...	6	5- 6	.....	0.90	1.25	2

There are no two pots of cow pea that may be regarded as duplicates. Pot 7 was inoculated with cowpea bacteria. The plants reached their maximum growth when the experiment was discontinued, in fact one plant had already died, but none had flowered. The roots were abundant considering the top growth, and extended six inches into the coal ashes of the bench. The nodules three in number were as large as garden pea seeds.

Pot 11 without inoculation developed its plants equally well as the preceding with a heavier development of roots and one nodule.

Pot 15 in which was planted cowpea seeds inoculated with soybean bacteria developed even stronger plants than either of the preceding and bore 10 large nodules.

Pots 19 and 26 are yet to be compared to show the effects of inoculation in greenhouse soil. These plants were strong, vigorous and green when taken from the pots for records. The roots extended 6-8 inches into the ashes of the benches. The nodules, 32 in number, with inoculation, and 28 without inoculation, ranged in size from that of red clover seed to that of a kidney bean. Even here the slight difference in favor of the inoculated pot cannot support the great claims made for "nitro-culture" on cotton.

Pot 23 is a case of inoculated seed in sterilized sand without any plant food whatever, except what could be obtained from hydrant water used daily.

FIELD EXPERIMENT.

On April 27, 1905, seeds of the four legumes used in the pot experiments, treated and untreated with the "nitro-culture" were planted in the field. A piece of land was chosen on which for several years past an annual crop of sweet corn had been grown, and preceding that for a period of about 12 years was devoted to blackberries and raspberries. So far as is known, it had never been planted to alfalfa, soy bean, vetch or cowpea. The land was marked off into plots 8 feet by 8 feet with a space of two feet between the plots, for the treated seed, and plots 8 feet by 48 feet for seed untreated.

PLAN OF FIELD PLOTS.

Seed.	Treatment like in Pot Experiment.	Size of plot.	Corresponding pot numbers.
Alfalfa,	Inoculated with alfalfa,	8 x 8 ft.	1
Alfalfa,	Inoculated with alfalfa,	8 x 8 ft.	2
Alfalfa,	Inoculated with vetch,	8 x 8 ft.	12
Alfalfa,	Not inoculated,	8 x 48 ft.	8
Soy bean,	Inoculated with soy bean,	8 x 8 ft.	3
Soy bean,	Inoculated with soy bean,	8 x 8 ft.	4
Soy bean,	Inoculated wuth alfalfa,	8 x 8 ft.	13
Soy bean,	Not inoculated,	8 x 48 ft.	9
Vetch,	Inoculated with vetch,	8 x 8 ft.	5
Vetch,	Inoculated with vetch,	8 x 8 ft.	6
Vetch,	Inoculated with alfalfa,	8 x 8 ft.	24
Vetch,	Not inoculated,	8 x 48 ft.	10
Vetch,	Inoculated with cow pea,	8 x 8 ft.	14
Cow pea,	Inoculated with cow pea,	8 x 8 ft.	7
Cow pea,	Inoculated with soy bean,	8 x 8 ft.	15
Cow pea,	Not inoculated,	8 x 48 ft.	11

The seeds germinated and vegetated so evenly and so uniformly over all the plots, that it was impossible to detect any differences that might be attributed to the treatment which the seed received.

On July 6, the following notes were recorded: The alfalfa plants were 8 inches to 12 inches high over all the alfalfa plots. No difference in color or vigor could be detected. Plants in all the plots were beginning to show blossoms.

The soy bean plants were 12 inches to 18 inches high uniformly over all the plots, looking equally green and thrifty everywhere. Many of the plants in each plot were in blossom.

The vetch plants at a height of 20 inches to 30 inches were in full

flower growing vigorously with a good green color everywhere, regardless of the treatment which the seed received.

The cowpea plants suffered from a late frost, May 21. At this date, July 6, the foliage was turning yellow, and though the plants were but 8 inches to 10 inches high, it is evident that not much new growth would be made. There was no observable difference in the plants of any two plots of the series.

Several plants in each plot were taken up, to determine the number of nodules on the roots with the following results:

NODULES ON FIELD PLANTS.

Pot numbers.	Legumes.	Treatment of Seed.	Average number of nodules clusters per plant.
1	Alfalfa,	Inoculated with alfalfa,	9
2	Alfalfa,	Inoculated with alfalfa,	4
12	Alfalfa,	Inoculated with vetch,	3
8	Alfalfa,	Not inoculated,	6
3	Soy bean,	Inoculated with soy bean,	133
4	Soy bean,	Inoculated with soy bean,	162
13	Soy bean,	Inoculated with alfalfa,	120
9	Soy bean,	Not inoculated,	50
5	Vetch,	Inoculated with vetch,	19
6	Vetch,	Inoculated with vetch,	27
24	Vetch,	Inoculated with alfalfa,	17
10	Vetch,	Not inoculated,	30
14	Vetch,	Inoculated with cow pea,	40
7	Cow pea,	Inoculated with cow pea,	3
15	Cow pea,	Inoculated with soy bean,	0
11	Cow pea,	Not inoculated,	12

The nodules on these field plants were in general larger than those on the pot plants. It is evident from the figures recorded for the clusters of nodules on the alfalfa, that plants show no advantage in the inoculation. It is remarkable that the soy beans which produced no nodules on any plants in the pot cultures show a decidedly heavy production of nodules on the field plants. These were large and uniformly distributed over the root systems. The figures in this case favor the inoculation. In the case of the vetch and cowpea there was no strong development of nodules.

SMALL FRUITS IN 1905.

BY J. PLUMMER PILLSBURY.

The kinds, and number of each, of the various small fruits under experimentation at this place during the past season, are as follows:

Strawberries,	48 varieties.
Raspberries,	27 varieties.
Blackberries,	20 varieties.
Dewberries,	2 varieties.
Currants,	12 varieties.
Gooseberries,	10 varieties.

Of the first named, thirty-three varieties fruited and fifteen were but newly planted. Among the raspberries, two were newly planted, two were winter killed so badly as to leave no fruiting wood, and one died.

Blackberries Sample and Early Harvest did not fruit on account of small size and winter killing, respectively.

Currants were all good and in all cases except those of the black fruited sorts, full notes were taken.

Of the Gooseberries, but one variety (which was almost dead) failed to fruit. All yields were small, however, and no full record was kept of them.

STRAWBERRIES.

The plot occupied by this fruit is the most uneven one in the Station garden and most of the best appearing sorts of former years were located upon the highest, driest and heaviest soil in it. Had the season been as dry as was the case a few years ago, the fruit of some of them would have dried up on the vines. However, such was not the case as the amount of rainfall was nearly normal.

Late frosts which occurred on and about May 22, made the season open late and caused a shortening of it in some cases. The degree of frost, which really was a "freeze" is indicated by the fact that asparagus located near by, and from two to six inches in height. was frozen to the ground. The result, which will not be so readily seen in the table of yields as in the daily record, is shown by the note recorded June 30, as follows: "The sudden drop in yields which began on the 23d (June) proves conclusively the anticipated effect of the cold weather during the corresponding period in last month."

The following table gives a summary of the notes taken upon the flower, fruit and growth during the season just passed. In the second column B indicates that the flower is bisexual or perfect, while P means pistillate or imperfect flowers. All weights are expressed in grains and of the scale used in the last three volumns, 1 indicates very little, few or weak and 10, the opposite.

Table No. 1.—Strawberries.

Variety.	B or P.	Date of first flower.	Date of first ripe.	Date of largest yield.	Date of last ripe.	Average weight of berries.	Yield of 54 ft. of row.	Rust 1 to 10.	Runners 1 to 10.	Vigor 1 to 10.
Adam's Favorite,..	P	May 6	June 9	June 19	July 7	6.47	15 695	3-4	7	8
Boynton, ...	P	May 3	June 2	June 12	June 28	3.03	8 915	3-4	6	6
Brandywine, ...	B	May 8	June 7	June 22	July 7	7.43	11 170	3-4	7	8
Crawford, ...	B	May 3	June 1	June 15	July 5	3.05	14 625	3-4	10	8
Crescent, ...	P	May 2	June 3	June 19	July 1	3.70	16 470	7-8	8	8
Ella, ...	B	April 30	May 31	June 7	June 26	1.87	10 885	2-3	8	8
Enhance, ...	B	May 3	June 7	June 19	July 7	4.52	15 600	5-6	9	8
E. P. Roe, ...	B	May 3	June 3	June 20	July 8	5.24	13 195	5-6	7	8
Ernest, ...	P	May 8	June 5	June 19	July 5	5.23	17 120	4-5	8	8
Eureka, ...	P	May 9	June 7	June 22	July 7	11.20	15 105	5-6	8	7
Greenville, ...	P	May 8	June 6	June 13	July 1	5.15	13 270	2-3	3	9
Harrison, ...	P	May 9	June 5	June 19	July 7	5.15	10 050	6-7	9	8
Henderson, ...	P	May 8	June 3	June 19	July 5	3.14	17 280	4-5	8	7
Hend. No. 12, ...	B	May 8	June 5	June 19	July 3	5.85	10 835	3-4	7	7
Hunn, ...	P	May 15	June 17	June 22	July 7	10.26	2 760	6-7	6	8
Leon XIII, ...	B	May 8	June 3	June 19	July 5	4.65	4 305	5-6	4	8
Mary, ...	P	May 9	June 8	June 19	July 7	8.77	6 215	4-5	7	9
Mt. Joy, ...	B	May 9	June 9	June 19	July 3	7.82	8 940	6-7	9	9
Ohio Centennial,..	B	May 9	June 9	June 19	July 7	10.40	7 675	4-5	5	7
Parker Earle, ...	B	May 10	June 10	June 26	July 7	12.06	8 385	5-6	10	10
Perkins No. 1, ...	P	May 13	June 12	June 22	July 5	12.75	11 720	3-4	4	8
Root, ...	....	May 13	June 15	June 20	June 26	11.07	.....	.....	.....	....
Sample, ...	P	May 9	June 8	June 19	June 27	7.72	9 585	5-6	7	10
St. Antoine, ...	B	May 1	June 7	June 17	June 28	2.91	360	7-8	4	8
St. Joseph, ...	B	May 9	June 13	June 26	July 7	8.77	1 430	5-6	9	7
See No. 4, ...	P	May 12	June 12	June 19	July 7	10.19	9 695	5-6	10	8
Shuster's Gem, ...	P	May 8	June 6	June 19	July 3	7.24	9 355	7-8	6	7
Smeltzer's Early,..	B	May 6	June 5	June 19	June 29	3.95	7 190	4-5	10	8
Townsend, ...	P	May 9	June 9	June 19	July 5	7.77	11 070	4-5	8	8
Van Deman, ...	B	May 8	June 3	June 19	July 3	5.57	14 505	7-8	7	7
Warfield, ...	P	May 9	June 6	June 19	July 7	4.70	12 310	5-6	8	7
White Fruit, ...	B	May 1	June 6	June 26	July 7	.89	800	2-3	8	2
Wm. Belt, ...	....	May 9	June 13	June 16	June 28	9.52	.....	.....	.....	....
Total, ...	....	.....	.....	.....	.....	217.54	323 885	139-160	226	239
Average, ...	....	.....	.....	.....	.....	6.56	10 448	4.49 5 16	7.29	7.71

In the next table is given the average weights of berries, of all varieties grown during the season just passed and which have been fruited the preceding four years, arranged according to rank of average.

Table No. 2.—Strawberries.

Variety.	Average Weight In					Average.
	1901.	1902.	1903.	1904.	1905.	
Perkins No. 1,	13.86	7.89	9.36	9.62	12.75	10.70
Parker Earle,	12.02	10.20	7.87	10.10	12.06	10.45
Brandywine,	13.54	10.76	7.69	11.80	7.43	10.24
Mary,	13.66	6.94	6.46	11.52	8.77	9.47
Ohio Centennial,	13.00	5.50	7.58	8.12	10.40	8.92
Hunn,	8.38	4.38	11.67	4.81	10.26	7.90
See No. 4,	10.19	4.50	6.75	7.43	10.19	7.81
Eureka,	10.93	4.53	5.99	5.56	11.20	7.64
Sample,	10.75	5.65	6.26	7.32	7.72	7.54
Townsend,	8.94	4.95	5.36	9.55	7.77	7.31
Enhance,	11.31	6.00	4.47	8.61	4.52	6.98
Mt. Joy,	10.79	6.41	4.13	4.59	7.82	6.75
Adam's Favorite,	7.98	4.10	5.32	6.70	6.47	6.11
Shuster's Gem,	7.29	2.40	5.73	5.88	7.24	5.71
Greenville,	9.53	2.78	4.40	5.88	5.15	5.55
St. Joseph,	7.50	5.96	5.39	.....	8.77	5.52
Warfield,	8.04	3.26	3.50	5.10	4.70	4.92
Van Deman,	7.32	3.21	3.70	4.22	5.57	4.80
Harrison,	7.81	3.97	3.86	2.73	5.15	4.70
Ernest,	7.83	2.12	3.30	4.48	5.23	4.59
E. P. Roe,	7.39	1.88	4.09	4.35	5.24	4.59
Leon XIII,	5.38	2.06	3.50	6.25	4.65	4.37
Henderson No. 12,	5.48	2.67	3.03	4.92	5.35	4.29
Crescent,	5.16	2.50	4.63	4.20	3.70	4.04
Henderson,	5.48	3.13	2.60	3.28	3.14	3.53
Smeltzer Early,	6.59	1.88	2.37	2.52	3.95	3.46
Crawford,	5.43	2.75	2.56	3.26	3.05	3.41
St. Antoine,	5.16	3.06	2.90	.....	2.91	2.81
Boynton,	3.58	1.11	2.02	2.75	3.03	2.50
Ella,	3.42	.96	2.30	3.83	1.87	2.48
White Fruit,	.98	.63	.66	.94	.89	.82
Total,	.....	.....	.....	.....	.....	182.00
Average,	.....	.....	.....	.....	.....	5.87

Notes.

Ernest.—This is one of the newest varieties. It was received from R. E. Rodgers, Snyder Creek, Pa., in 1898, and its record shows it to have been doing quite well. Size of berries below medium, however.

Harrison.—Received in 1897 from Geo. W. Adams, Tamaqua, Pa. Said to have been remarkable for its freedom in producing runners, but in this soil not exceeding several others grown here, in this respect. Berries are not as large as should be.

Henderson No. 12.—Received from Peter Henderson & Co., New York, N. Y., in 1898. Considered here as being as good or better than the older sort known as Henderson. Average size is a little low.

Hunn.—Sent for trial, by Birdseye & Son, Hopewell, P. O., N. Y., in 1898. Our best very late sort. The yield is not up to the mark desired however. The average weight of its very solid berries is good.

Leon XIII.—One of a number of "Novelty" varieties received from the Department of Agriculture (U. S.) in 1899. All are French varieties and descendants of Fragaria vesca. Do not yield enough, nor do the berries come up to the mark in regard to size, color, or solidity.

Root.—Received from A. W. Root & Bro., Manheim, Pa., in 1902. Berries large to very large, broad, round conical, light in color, firm to solid, seeds many and prominent, flavor mild and fair.

St. Antoine De Padone.—One of the French varieties mentioned above.

St. Joseph.—Another of the same.

White Fruit.—A "miniature" variety in all respects and a decided novelty. Another French sort.

Wm. Belt.—Received same as "Root." Berries very large, somewhat irregular, broad to wedge shaped, firm, bright in color, and of fine quality. Yield will be reported later.

RASPBERRIES.

The new plantation is now in a flourishing condition and good strong growth has been made in most cases in spite of the fact that crown gall has attacked all varieties. Columbian seems to have succumbed to it and the severity of the winter in this locality. The rest do not show any signs of giving up but have made healthy normal growths and yielded good crops of fruit.

The height of all varieties has been raised to four feet, and the results so far have been good. As soon as the crop is off, all the old canes are cut out and the new ones tied up, the ground cultivated once or twice thoroughly, and hoed to keep down the weeds for the rest of the season. In the early spring from four to six of the strongest canes are left after pruning down to live buds or by cutting off about one-third. The rest are then cut out entirely. After tying up, the ground is thoroughly worked up and kept in fine tilth until picking begins. During the picking season at which time new growths reach the proper height, the tips of these are pinched off; thus checking growth which is diverted into the side shoots and to the better development of the canes.

The following table gives the result of this season's observations.

Table No. 3.—Raspberries.

Variety.	Color.	Date of first flower.	Date of first ripe.	Date of largest yield.	Date of last ripe.	Average weight of berries.	Yield of 12 plants.	Rust 1 to 10.	Vigor 1 to 10.
All Summer,	P	May 22	July 2	July 17	Sept. 26	2.42	10,720	1	8-9
Columbian,	P	June 5	July 5	July 15	July 27	1.67	9,770	3-4	3-4
Cuthbert,	R	June 3	July 4	July 15	Aug. 5	2.63	24,780	1	10
Eaton,	R	May 26	July 3	July 17	Aug. 5	2.45	18,170	1	8-9
Golden Queen,	Y	June 5	July 5	July 15	Aug. 4	1.67	13,295	3-4	7-8
Hansell,	R	May 25	July 2	July 15	Aug. 5	1.85	6,575	2-3	6-7
King,	R	June 2	July 1	July 7	Aug. 4	1.83	6,880	3-4	8-9
Loganberry,	P							7-8	5-6
London,	R	June 3	July 3	July 15	Aug. 7	2.36	11,075	1	7-8
Millers,	R	June 1	July 1	July 17	Aug. 11	1.80	10,860	1	7-8
Shaffer,	P	June 4	July 3	July 10	Aug. 4	2.07	25,300	5-6	10
Turner,	R	June 3	July 3	July 17	Aug. 4	1.37	15,145	1	7-8
"Yellow,"									
Black Diamond,	B	May 26	June 30	July 5	July 22	1.81	14,520	2-3	7-8
Conrath,	B	May 23	June 25	July 5	July 20	1.64	6,615	2-3	7-8
"Beyer,"									
Eureka,	B	May 26	June 25	July 5	July 15	1.16	4,220	5-6	7-8
Gregg,	B	May 27	July 1	July 10	July 15	1.69	12,100	2-3	8-9
Kansas,	B	May 25	June 26	July 5	July 20	1.08	5,075	2-3	7-8
Mammoth Cluster,	B	May 22	June 23	July 5	July 15	1.07	7,030	4-5	5-6
Mills,	B	May 24	June 26	July 5	July 21	1.25	11,265	2-3	7-8
Older,	B	May 22	June 26	July 5	July 19	1.71	15,395	5-6	7-8
Onondago,	B	May 25	June 28	July 5	July 19	1.80	20,300	2-3	7-9
Palmer,	B	May 20	June 24	July 5	July 13	.96	7,480	3-4	6-7
Brackett's 101,	B	May 27	June 30	July 5	July 15	1.38	4,080	2-3	7-8
Wineberry,	O							1	5-6
"Chestnut,"								3-4	6-7

Notes.

All Summer.—This variety was described as an everbearing sort. Since planting in the new bed full record of its behavior has been kept and a summary of its yield is given below. It is very vigorous and hardy. The berries are large, red and purple, and of good form and flavor while the season extends from about July 1, until frost. The weights given are in grains and represent the yield of 12 plants.

Year.	July.	August.	September.	October.
1903,	625	735	2,525	690
1904,	5,760	1,165	515	.....
1905,	8,090	1,760	395	.....
Total,	14,475	3,660	3,435	.....
Average,	4,825	1,220	1,145	.....

Columbian.—This variety has proved too tender for this locality without protection. As stated above "crown gall" has attacked and nearly destroyed it.

Eaton.—Received for trial from Amos Garretson, Pendleton, Ind. A vigorous and healthy variety. Berries are large, red and of good quality. The yield is good but does not approach Shaffer in this respect at this place.

King.—A red fruited variety acquired by purchase. Growth vigorous and healthy, but it has been disappointing in yield so far.

Loganberry.—This variety was left unprotected last winter with the usual result, viz: that of being frozen to the ground. Good growth has been made, however, and a fair crop may be expected next year.

London.—Another red fruited sort acquired by purchase for purposes of comparison.

Shaffer.—A large, vigorous, purple fruited variety which is now well known. Its yield is the largest of any at this place.

"Yellow"—Received from H. C. Rathman, Knaurs, Pa. It was completely frozen out last winter. As it had never made good growth it readily succumbed.

"Beyer."—Received for trial, from Hugo Beyer, New London.

Iowa.—Not yet large enough for report.

"Chestnut."—Sent for trial by J. F. Chestnut, Keene, Tex. Same as preceding.

BLACKBERRIES.

The Dewberries are included under this head.

This fruit is given practically the same treatment as the raspberries, and all are planted five feet, in rows six feet apart. No crown gall has been found on any of the blackberries, and all are in good condition with one or two exceptions.

The following table gives the record of observations for the season just passed.

Table 4.—Blackberries.

Variety.	Color.	Date of first flower.	Date of first ripe.	Date of largest yield.	Date of last ripe.	Average weight of berries.	Yield of 6 plants.	Rust 1 to 10.	Vigor 1 to 10.
Agawam,	B	May 24	July 15	July 17	Aug. 21	2.33	3,010	2-3	8-9
Allen,	B	May 24	July 15	July 24	Aug. 18	2.17	6,090	4-5	7-8
Ancient Briton,	B	May 27	July 19	July 31	Aug. 11	2.64	5,170	3-4	8-9
Child's Tree,	B	June 2	July 21	Aug. 4	Aug. 21	2.95	1,395	5-6	8-9
Clark,	B	June 2	July 18	July 24	Aug. 21	3.2	1,240	4-5	7-8
Crystal White,	W	June 4	July 21	July 27	Aug. 2	1.39	570	1	4-5
Dorchester,	B	May 27	July 17	July 21	Aug. 5	2.34	3,040	4-5	6-7
Early Cluster,	B	June 1	July 19	July 24	Aug. 18	2.03	1,610	5-6	5-6
Early Harvest,	B	.....	.....	.....	.....	.....	.....	4-5	.....
Early King,	B	June 2	July 18	July 24	Aug. 18	1.95	990	3-4	7-8
Eldorado,	B	May 27	July 17	July 24	Aug. 21	2.55	2,665	2-3	8-9
Erie,	B	June 1	July 18	July 24	Aug. 21	5.18	5,335	5-6	7-8
Kittatinny,	B	May 27	July 19	July 24	Aug. 21	3.53	2,350	2-3	8-9
Lovett's Best,	B	June 2	July 19	July 29	Aug. 18	3.47	2,615	2-3	7-8
Ohmer,	B	May 29	July 19	July 24	Aug. 18	2.23	6,000	2-3	7-8
Rathbun,	B	May 29	July 18	July 24	Aug. 11	3.11	7,080	7-8	5-6
Snyder,	B	May 26	July 17	July 24	Aug. 18	2.39	7,835	2-3	7-8
Wilson,	B	May 26	July 17	July 21	Aug. 16	2.31	6,175	3-4	7-8
Wilson, Jr.,	B	May 27	July 17	July 21	July 25	.....	1,260	3-4	5-6
Sample,	B	.....	.....	.....	.....	.....	.....	5-6	1
Austin's Improved,	B	May 30	July 6	July 12	July 15	.....	90	3-4	8-9
Lucretia,	B	May 28	July 6	July 17	July 19	.....	1,680	5-6	5-6

Notes.

Allen.—Received from W. B. K. Johnson, Allentown, Pa. A good early variety which closely resembles Early Harvest in all except its lack of hardiness.

Clark.—Received from M. Crawford, Cuyahoga Falls, O. Berries are large and fine and growth is vigorous and healthy, but its yield is not of the best, to say the least.

Crystal White.—A novelty. The berries are white, but the variety is not entirely hardy or productive enough.

Early Harvest.—Very early and a good sort, but it is too tender for this locality.

Erie.—Produces the largest berries of any variety grown here.

Rathbun.—Acquired by purchase. Yield good and in fact the only fault to find with it is its weak habit.

Snyder.—The best yielding variety this year.

"Sample."—Received from E. E. Carr, North East, Pa., in 1901. No report can be made at this time.

Austin Improved.—A dewberry received from J. W. Austin, Pilot Point, Tex., growth very vigorous and yield practically nothing.

Lucretia.—A well known dewberry which does not do well here.

CURRANTS.

This season the imported currant worm (Nematus ventricosus) obtained a good start after the fruit was partly developed and owing to the impossibility of using an arsenite it was only overcome after the loss of a good deal of foliage was sustained.

This was especially true of the gooseberries and the yield suffered so much in consequence, that no report of it is made at this time.

The tables give the general notes on the varieties grown here this year. The black fruited sorts were not picked; hence no record of yield is given.

Table No. 5.—Currants.

Variety.	Color.	Date of first flower.	Date of first ripe.	Date of last ripe.	Yield of 6 plants.	Rust 1 to 10.	Vigor 1 to 10.
Storrs & Harrison,	R	April 25	June 17	July 6	54,360	2-3	8-9
Victoria,	R	April 25	June 17	July 6	31,005	2-3	8-9
Versailles,	R	April 26	June 16	July 6	16,390	2-3	7-8
Red Dutch,	R	April 25	June 15	July 5	21,265	2-3	5-6
Black Naples,	B	May 1	July 1	July 15	.....	0	10
Cherry,	R	April 25	June 19	July 5	19,160	3-4	7-8
White Grape,	W	April 28	June 20	July 7	10,940	5-6	5-6
Lee's Prolific,	B	May 1	July 1	July 15	.....	0	8-9
Black Champion,	B	May 1	July 1	July 15	.....	0	10
Fay's Prolific,	R	April 26	June 16	July 5	12,240	3-4	7-8
Red Grape,	R	April 24	June 14	July 5	34,700	3-4	7-8
Crandall.	B	April 26	July 1	July 10	.....	0	10

Storrs and Harrison.—Received from the firm of that name, located in Painesville, O., for trial. It has been grown here for a number of years and has done very well indeed. The above record speaks for itself. Berries medium in size.

Cherry and Fay's Prolific.—Are large fruited sorts and are considered the best grown here.

GOOSEBERRIES.

The following table of notes on the gooseberries requires no explanation. However it might be mentioned that Golden Prolific was nearly dead and that Crystal and Wellington, although good growth has been made, have never yielded a crop worth recording.

Table No. 6.—Gooseberries.

Variety.	Size.	Shape.	Color.	Date of first flower.	Date of first ripe.	Date of last ripe.	Height in feet.	Rust 1 to 10.	Vivor 1 to 10
Smith,	Medium,	Oval,	Green,	April 26	June 28	July 10	3	5-6	7-8
Downing,	Medium,	Round,	Green,	April 28	July 1	July 12	3½	3-4	7-8
Houghton,	Small,	Round,	Red,	April 29	June 30	July 10	3½	5-6	8-9
Triumph,	Large,	Round to oval.	Yellowish,	April 28	July 1	July 12	2½	10	5-6
Golden Prolific,	Large,	Round,	Greenish,	.....	.....	.....	....	.....	....
Chautauqua,	Large,	Oval,	Greenish,	April 28	July 2	July 12	2½	10	4-5
Roesch,	Large,	Oval,	Yellowish,	April 27	July 2	July 12	2½	5-6	5-6
Pearl,	Medium,	Round,	Green,	April 26	July 3	July 12	3	5-6	7-8
Crystal,	Medium,	Round,	Green,	April 28	July 3	July 12	2½	10	3-4
Wellington,	Large,	Oval,	Green,	.....	.....	.....	2½	9	5-6

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MISS ELIZABETH F. JONES,* } Stenographers.
MISS EVA JONES,† } Stenographers.
MISS ALICE R. JONES. } Stenographers.
MISS M. ISABEL INNES. } Stenographers.

REPORT OF THE SECRETARY.

To the Director:

Sir: In making this report upon the office and library of the Station, it is gratifying to be able to state that, in spite of the fact that an entire change in its stenographic force took place during the year, the work has been carried in a very satisfactory manner. The amount of correspondence shows a decided increase over that of last year, owing to the necessary correspondence in connection with the Adams bill. More than one thousand new names have been added to the mailing list during the year, a large portion of which were names of students in the correspondence courses in agriculture. It is the endeavor to mail bulletins to all of those taking these courses. The mailing list now comprises over 17,000 names, necessitating an increase in the edition of the last Bulletin (No. 77).

In the latter part of this year, the mailing room was transferred from the cellar of the Station building to the old dairy building. With a few changes, this building was put in very fair condition and it now affords ample facilities for mailing and preserving the publications of the Station.

As was mentioned in the last report, the Elliott system of addressing was initiated in the mailing department in 1904, a part of the list being at that time made into stencils. The balance of the list of over nine thousand addresses has this year been made into stencils. Although the cost of establishing this system has been somewhat large, it is believed that, in the long run, there will be a saving of labor which will offset the extra expenditure. The list is much more easily handled and the cost of adding names to the list will be trifling.

Although the expenditure for office equipment may have been somewhat larger than usual this year, owing to the purchase of a new typewriter and new comptometer, yet these additional conveniences have aided materially in the accomplishment of good work, and it is not anticipated that so large an expenditure will need to be made again in several years.

During the year, the balance of the earlier numbers of the bul-

*To Sept. 1, 1905.
†To Aug. 12, 1905.

letins and reports of other experiment stations, 33 volumes in all, have been placed in the uniform binding adopted for that purpose several years ago, and we are now able to preserve these publications in good condition, a matter of much importance, since they are in frequent use as works of reference.

The following is a list of periodicals to which the Station has subscribed regularly for a number of years:

Milch Zeitung.
Gardener's Chronicle.
Botanische Zeitung.
The Analyst.
Zeitschrift für Analytische Chemie.
Jahresbericht der Landwirtschaft.
Pflüger's Archiv für Physiologie.
Landwirtschaftliche Jahrbücher.
Journal für Landwirtschaft.
Journal d'Agriculture Pratique.
Biedermann's Centralblatt.
Zeitschrift für Physiologische Chemie.
Jahresbericht über die Fortschritte Agr. Chemie.
Mittheilungen der Landw. Institut der Universität Leipzig.
Jahrbuch der Agr. Chemischen Versuchstation Hallé.
Berichte, etc., der Universität Königsburg.
Mittheilungen der Universität Breslau.
Centralblatt für Bakteriologie Parasitenkunde u. Infektionskrankheiten.
Mittheilungen der Vereinigung Deutschen Landw. Versuchs.
Zeitschrift für das Landw. Versuchswesen.

In addition to the above list, there have been placed in the library during the year the following periodicals:

Naturwissenschaftliche Zeitschrift für Landw. und Forstwirtschaft.
Milchwirtschaftliches Zentralblatt.
The Journal of Biological Chemistry.
The American Journal of Physiology.

More than fifty volumes of the above periodicals are now at the binder's and when these are returned to us our small amount of available shelf room will be taxed to overflowing. By another year, it will be necessary to provide additional space in the book room.

Two new cabinets have been added to the library equipment in which the card catalogue of the following three periodicals prepared by the U. S. Department of Agriculture is now being arranged:

Die landwirtschaftlichen Versuchs Station.
Annales de la Science Agronomique.
Landwirtschaftliche Jahrbücher.

The following bulletins have been published by the Station:

72. Experiments in Growing Sumatra Tobacco under Shelter Tent, 1903.

73. Distillers' Dried Grains vs. Cottonseed Meal as a Source of Protein.

74. Methods of Steer Feeding.

75. Forage and Soiling Experiments, 1904.
76. Variety Tests of Wheat, Oats and Potatoes.
77. Small Fruits in 1905.

Press Bulletins.

Relative Values of Feeding Stuffs.
Rice Hulls—A Dangerous Adulteration.
Nitro Cultures.
Variety Tests of Wheat, Oats and Potatoes.
Dried Distillers' Grains.
Commercial Feeding Stuffs.
Soiling Crops of Pennsylvania.
Co-operative Fertilizer Tests.
Small Fruits.

The following newspapers have been received in exchange for the bulletins of the Station:

Agricultural Advertising, Chicago, Illinois.
Agricultural Epitomist, Indianapolis, Indiana.
Agricultural Journal of India.
Agricultural News, Barbadoes.
Agricultural Student, Columbus, Ohio.
American Agriculturist, New York.
American Fancier, Johnstown, N. Y.
American Fertilizer, Philadelphia, Pa.
American Grange Bulletin and Scientific Farmer, Cincinnati, O.
American Hay, Flour and Feed Journal, New York.
American Sheep Breeder and Wool Grower, Chicago, Ills.
Beet Sugar Gazette, Chicago, Ills.
Blooded Stock, Oxford, Pa.
Breeders' Gazette, Chicago, Ills.
California Cultivator and Poultry Keeper, Los Angeles, Cal.
Chicago Produce, Chicago, Illinois.
Coleman's Rural World, St. Louis, Mo.
The Cornell Countryman, Ithaca, N. Y.
The Country Gentleman, Albany, N. Y.
The Creamery Journal, London, England.
Elgin Dairy Report, Elgin, Illinois.
Farm and Home, Melbourne, Australia.
Farm, Stock and Home, Minneapolis, Minnesota.
Farm Life, Chicago, Illinois.
Farmer and Stockman, Kansas City, Missouri.
Farming, New York.
Farm, Garden and Poultry, Hammonton, N. J.
Farm and Stock, St. Joseph, Missouri.
Farm Journal, Philadelphia, Pa.
Farm, Field and Fireside, Chicago, Ills.
Farm and Fireside, Springfield, Ohio.
Farmers' Advocate, London, Canada.
Farmer's Friend and Grange Trade Bulletin, Mechanicsburg, Pa.
Farmer's Guide, Huntingdon, Ind.
Farmer's Review, Chicago, Illinois.
Farmer's Sentinel, Milwaukee, Wisconsin.
Farmer's Tribune, Des Moines, Iowa.

Flour and Feed, Waukegan, Illinois.
Flour Trade News, New York.
Gleanings in Bee Culture, Medina, Ohio.
Hoard's Dairyman, Fort Atkinson, Wisconsin.
Holstein-Friesian Register, Brattleboro, Vt.
Holstein-Friesian World, Ithaca, N. Y.
Homestead, Des Moines, Iowa.
Hospodar, Omaha, Nebraska.
Indiana Farmer, Indianapolis, Ind.
Industrialist, Manhattan, Kansas.
Irrigation Age, Chicago, Illinois.
Jersey Bulletin, Indianapolis, Indiana.
Journal of the Department of Agriculture, Victoria, Australia.
Kansas Farmer, Topeka, Kansas.
Kimball's Dairy Farmer, Waterloo, Iowa.
La Laiterie, Paris, France.
Louisiana Planter, New Orleans, La.
The Metropolitan and Rural Home, New York.
Michigan Farmer, Detroit, Mich.
National Farmer and Stock Grower, St. Louis, Mo.
National Stockman and Farmer, Pittsburg, Pa.
The Natal Agricultural Journal and Mining Record, South Africa.
New England Farmer, Boston, Mass.
New Hampshire Farmer, Manchester, N. H.
New Hampshire Sanitary Bulletin, Concord, N. H.
New York Farmer, Port Jervis, N. Y.
New York Produce Review and American Creamery, New York.
New Zealand Dairyman, Wellington, N. Z.
Nut Grower, Poulan, Georgia.
Orange Judd Farmer, Chicago, Illinois.
Oregon Agriculturist, Portland, Oregon.
Pennsylvania Farmer, Meadville, Pa.
Pennsylvania School Journal, Lancaster, Pa.
Poultry Husbandry, Waterville, N. Y.
Practical Farmer, Philadelphia, Pa.
Practical Fruit Grower, Springfield, Missouri.
Prairie Farmer, Chicago, Illinois.
Public Ledger, Philadelphia, Pa.
Reliable Poultry Journal, Quincy, Illinois.
Rural New Yorker, New York.
Rural World, London, England.
Southern Fruit Grower, Chattanooga, Tennessee.
Southern Planter, Richmond, Va.
Successful Farming, Des Moines, Iowa.
Sugar Beet, Philadelphia, Pa.
Swine Breeders' Journal, Indianapolis, Indiana.
Texas Farmer, Dallas, Texas.
Transvaal Agricultural Journal, South Africa.
Tribune Farmer, New York.
Veterinary Record, London, England.
Wallace's Farmer, Des Moines, Iowa.
Western Fruit Grower, St. Joseph, Mo.
Adler, Reading, Pa.
Advance, Leechburg, Pa.

Bedford Inquirer, Bedford, Pa.
Democrat, Clarion, Pa.
Democrat, Indiana, Pa.
Democrat, Johnstown, Pa.
Erie Weekly Herald, Erie, Pa.
Free Press, Detroit, Pa.
Free Press, Quakertown, Pa.
Monitor, Clearfield, Pa.
Reading Weekly News, Reading, Pa.
Republican, Clearfield, Pa.
Tablet, Millville, Pa.
Weekly Witness, New York.
Windber Era, Windber, Pa.
Delaware County Democrat, Chester, Pa.
Juniata Herald, Mifflintown, Pa.
Democrat News, Chambersburg, Pa.
Lititz Express, Lititz, Pa.
Village Record, West Chester, Pa.
Advertiser, Sharpsville, Pa.
Weekly News, Reading, Pa.
Evening Telegraph, Philadelphia, Pa.
Dispatch, York, Pa.
Advance Farmer, Chicago, Illinois.

APPENDIX.

DETAILED METEROLOGICAL RECORDS

FOR 1905.

Meteorological Records for 1905—Barometric Pressure in Inches—Corrected and Reduced.

Dates.	January.			February.			March.			April.		
	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.
1,	29.967	29.870	29.888	30.329	30.144	30.236	30.005	30.072	30.038	30.324	30.320	30.322
2,	29.749	29.587	29.668	30.303	30.393	30.348	31.211	30.068	30.639	30.411	30.281	30.346
3,	29.731	29.817	29.774	30.546	30.532	30.539	30.051	30.002	30.026	30.244	29.928	30.086
4,	30.041	30.202	30.121	30.588	30.520	30.554	29.646	30.196	29.921	29.764	29.752	29.758
5,	30.332	30.341	30.336	30.620	30.270	30.445	30.262	30.040	30.151	29.808	29.637	29.722
6,	30.209	29.811	30.010	30.027	30.135	30.081	30.418	30.453	30.435	29.554	29.683	29.618
7,	29.353	29.655	29.504	30.346	30.558	30.452	30.357	30.150	30.253	29.775	29.737	29.756
8,	29.926	30.350	30.138	30.585	30.187	30.386	29.960	29.983	29.971	29.889	29.887	29.888
9,	30.656	30.435	30.545	30.017	29.843	29.930	30.111	29.817	29.964	29.963	29 793	29.878
10,	30.543	30.690	30.616	30.015	30.302	30.158	29.813	30.049	29.931	29.767	29.611	29.689
11,	30.695	30.379	30.537	30.561	30.465	30.513	30.312	30.347	30.329	29.552	29.619	29.585
12,	29.979	30.090	30.034	30.200	29.626	29.913	30.375	30.348	30.361	29.831	29.730	29.780
13,	30.328	30.320	30.324	29.625	29.867	29.746	30.504	30.327	30.415	29.742	29.623	29.682
14,	30.317	30.487	30.402	30.258	30.025	30.141	30.389	30.440	30.414	29.747	29.796	29.771
15,	30.410	30.298	30.354	30.052	30.321	30.186	30.622	30.450	30.536	29.917	27.806	28.861
16,	30.262	30.159	30.210	30.529	30.236	30.382	30.406	30.190	30.298	29.748	29.749	29.748
17,	30.252	30.183	30.217	29.986	30.004	29.995	30.224	30.039	30.131	29.844	30.003	29.923
18,	30.304	30.101	30.202	30.333	30.496	30.414	29.984	29.689	29.836	30.005	30.193	30.099
19,	29.836	29.807	29.821	30.696	30.580	30.638	29.747	29.741	29.744	30.249	30.057	30.153
20,	29.924	30.021	29.972	30.441	30.253	30.347	29.926	30.017	29.971	29.937	29.803	29.871
21,	30.040	30.059	30.049	30.286	30.211	30.248	29.920	29.957	29.938	29.676	29.732	29.704
22,	30.077	29.265	29.671	30.187	30.195	30.191	30.156	30.191	30.173	30.241	30.251	30.246
23,	30.405	30.244	30.324	30.217	30.161	30.189	30.265	30.206	30.235	30.457	30.361	30.409
24,	29.985	29.802	29.893	30.231	30.061	30.146	30.080	30.067	30.073	30.359	30.100	30.229
25,	30.883	30.117	30.450	29.920	29.673	29.796	31.113	29.952	30.532	30.149	29.627	29.888
26,	30.325	30.463	30.394	29.806	29.981	29.893	29.905	29.767	29.836	29.777	29.609	29.693
27,	30.254	30.039	30.146	30.111	29.937	30.024	29.920	29.967	29.943	29.543	29.563	29.553
28,	30.052	30.314	30.183	29.857	30.011	29.934	30.059	29.950	30.004	29.844	29.762	29.803
29,	30.492	30.347	30.419	.....	.....	.....	30.141	29.885	30.013	29.640	29.734	29.687
30,	30.506	30.562	30.534	.....	.....	.....	29.960	30.199	30.079	29.879	29.933	29.906
31,	30.535	30.419	30.477	.....	.....	.....	30.386	30.189	30.287	.....	.....	.....
Means,	30.203	30.137	30.168	30.238	30.178	30.208	30.201	30.089	30.144	29.921	29.789	29.855

Meteorological Records for 1905—Barometric Pressure in Inches—Continued.

Dates.	May.			June.			July.			August.		
	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.
1.	30.153	.....	.....	30.023	29.982	30.002	29.972	29.882	29.927	29.964	29.889	29.927
2.	30.181	29.915	30.048	29.943	29.959	29.951	29.872	29.859	29.865	30.030	29.947	29.988
3.	29.892	29.829	29.860	30.206	30.084	30.145	29.942	29.872	29.907	30.019	29.956	29.988
4.	29.946	29.917	29.931	30.041	29.912	29.976	29.911	29.940	29.925	30.018	29.945	29.981
5.	30.236	30.117	30.176	29.896	29.673	29.784	29.943	29.958	29.950	29.967	29.878	29.923
6.	30.119	29.888	30.003	29.631	29.849	29.740	29.984	29.925	29.954	29.842	29.830	29.836
7.	29.914	30.000	29.957	29.865	29.794	29.829	29.867	29.835	29.851	29.891	29.902	29.896
8.	30.041	29.773	29.907	29.984	30.053	30.018	29.929	29.901	29.915	29.984	29.995	29.990
9.	30.014	29.996	30.005	30.234	30.063	30.148	29.951	29.954	29.952	30.018	29.983	30.000
10.	30.202	30.188	30.195	30.025	29.953	29.989	30.008	31.011	30.509	30.058	30.068	30.063
11.	30.133	29.930	30.031	29.820	29.746	29.783	30.034	29.988	30.011	30.092	30.024	30.058
12.	29.895	29.875	29.885	29.759	29.716	29.737	30.027	29.982	30.004	30.008	29.924	29.966
13.	30.149	29.956	30.052	29.826	29.860	29.843	30.060	30.056	30.058	29.969	29.970	29.970
14.	29.872	29.852	29.862	30.021	30.000	30.010	30.086	30.039	30.062	30.002	29.873	29.937
15.	29.758	29.832	29.795	30.118	29.997	30.057	30.099	30.067	30.083	29.700	29.608	29.654
16.	29.778	29.761	29.769	30.043	29.942	29.992	30.102	29.982	30.042	29.787	29.971	29.879
17.	29.808	29.686	29.747	30.012	29.932	29.972	29.960	29.922	29.941	30.120	30.143	30.132
18.	29.709	29.760	29.734	29.998	29.931	29.964	29.976	29.902	29.939	30.177	30.088	30.132
19.	29.823	29.814	29.818	29.940	29.915	29.927	29.905	29.857	29.881	30.068	29.926	29.997
20.	29.834	30.045	29.939	29.980	29.901	29.940	29.884	29.841	29.862	29.931	29.951	29.941
21.	30.089	29.932	30.010	29.838	29.770	29.804	29.944	29.881	29.912	30.073	29.985	30.029
22.	30.026	29.975	30.000	29.794	29.823	29.808	29.927	29.888	29.907	30.042	30.049	30.045
23.	30.045	30.064	30.054	30.026	30.034	30.030	29.912	29.890	29.901	30.080	29.995	30.038
24.	30.221	30.042	30.131	20.177	30.048	30.112	30.017	29.933	30.020	29.989	29.978	29.983
25.	30.062	29.948	30.005	30.010	29.858	29.934	29.995	30.012	30.003	30.006	29.934	29.970
26.	29.945	30.038	29.991	29.629	29.788	29.708	30.087	30.018	30.052	30.089	30.013	30.051
27.	30.067	29.986	30.026	29.969	30.011	29.990	30.116	30.000	30.058	30.103	30.156	30.130
28.	30.043	29.967	30.005	30.059	30.015	30.037	30.044	29.948	29.996	30.233	30.033	30.133
29.	30.087	29.749	29.918	30.091	29.966	30.028	29.872	29.767	29.819	29.965	29.906	29.936
30.	29.881	29.896	29.888	31.056	29.900	30.478	29.673	29.625	29.649	29.816	29.657	29.736
31.	29.979	30.012	29.995	.....	.....	.....	29.691	29.824	29.757	29.848	29.959	29.904
Means.	29.997	29.925	29.958	30.000	29.915	29.958	29.964	29.954	29.958	29.996	29.953	29.974

Meteorological Records for 1905—Barometric Pressure in Inches—Continued.

Dates.	September.			October.			November.			December.		
	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.
1.	30.017	29.994	30.006	30.125	30.072	30.098	29.854	30.039	29.947	30.896	30.686	30.791
2.	29.950	29.885	29.917	30.115	30.007	30.061	30.260	30.154	30.207	30.486	30.244	30.365
3.	29.875	29.895	29.885	30.132	30.013	30,073	30.036	30.010	30.023	29.866	29.984	29.925
4.	29.917	29.995	29.956	30.002	29.889	29.945	30.121	30.255	30.193	30.194	30.377	30.286
5.	30.025	30.033	30.029	29.922	30.006	29.964	30.387	30.069	30.228	30.600	30.575	30.588
6.	30.031	30.062	30.047	30.238	30.293	30.266	29.682	29.841	29.762	30.497	30.367	30.432
7.	30.140	30.060	30.100	29.313	30.205	29.774	29.832	29.724	29.778	30.383	30.320	30.352
8.	30.131	30.186	30.158	30.210	30.115	30.162	29.737	29.930	29.834	30.320	30.274	30.297
9.	30.290	30.217	30.254	30.152	30.055	30.104	30.056	30.173	30.115	30.214	29.949	30.082
10.	30.238	30.090	30.164	30.076	29.885	29.980	30.316	30.354	30.335	29.813	29.939	29.876
11.	29.899	29.801	29.850	29.620	29.739	29.680	30.315	30.122	30.218	29.696	29.728	29.712
12.	29.914	29.934	29.924	29.829	29.925	29.877	30.017	29.669	29.843	29.766	29.807	29.787
13.	29.953	30.188	30.070	30.080	29.991	30.035	29.726	29.671	29.699	30.028	30.189	30.109
14.	30.378	30.259	30.319	30.232	30.230	30.231	30.092	30.027	30.060	30.382	30.454	30.418
15.	30.264	30.161	30.212	30.214	30.026	30.120	29.835	29.517	29.676	30.474	30.397	30.436
16.	30.154	30.100	30.127	30.130	30.232	30.181	29.474	29.729	29.602	30.381	30.334	30.357
17.	30.057	30.018	30.038	30.374	30.184	30.279	29.961	29.816	29.888	30.260	30.074	30.167
18.	30.022	30.005	30.013	30.140	29.897	30.019	29.954	29.995	29.975	29.992	29.985	29.989
19.	30.050	29.923	29.987	30.008	29.829	29.918	30.127	30.198	30.163	30.057	30.147	30.102
20.	29.920	29.994	29.957	29.646	29.905	29.776	30.389	30.465	30.427	30.285	30.164	30.225
21.	30.055	29.960	30.007	30.120	30.126	30.123	30.605	30.624	30.615	29.590	29.649	29.620
22.	29.925	29.858	29.893	30.097	30.015	30.056	30.598	30.326	30.462	29.907	29.998	29.953
23.	30.048	30.070	30.059	30.094	30.109	30.101	30.356	30.308	30.332	29.665	29.865	29.765
24.	30.095	29.888	29.992	30.102	30.079	30.091	30.068	29.838	29.953	30.013	30.105	30.059
25.	30.013	30.132	30.073	30.120	30.150	30.135	29.992	29.928	29.960	30.034	30.146	30.090
26.	30.155	30.099	30.127	30.151	30.126	30.138	29.885	29.902	29.894	30.169	30.022	30.096
27.	30.089	29.979	30.034	30.191	30.192	30.192	30.220	30.365	30.293	30.096	30.093	30.095
28.	30.102	30.031	30.066	30.277	30.414	30.245	30.189	30.065	30.127	31.222	29.921	30.572
29.	30.146	30.059	30.103	30.582	30.476	30.529	29.654	29.778	29.716	29.460	29.467	29.464
30.	30.145	30.140	30.142	30.465	30.305	30.385	30.256	30.717	30.487	29.700	29.938	29.819
31.	.....	.....	.....	30.122	29.947	30.035	.....	.....	.....	30.067	30.054	30.061
Means,	30.067	30.034	30.050	30.093	30.078	30.085	30.066	30.054	30.060	30.146	30.105	30.126

Meteorological Records for 1905—Temperature in Degrees Fahrenheit.

Dates.	January.						February.					
	8 A. M.	8 P. M.	Maximum.	Minimum.	Mean.	Range.	8 A. M.	8 P. M.	Maximum.	Minimum.	Mean.	Range.
1.	44	48	49	43	46.0	6	15	21	27	11	19.0	16
2.	48	40	44	41	42.5	3	3	1	22	.....	.....	.....
3.	19	11	.....	11	.....	.....	—3	7	7	—4	1.5	11
4.	5	15	19	4	11.5	15	0	6	7	—1	3.0	8
5.	14	19	21	14	17.5	7	—3	12	13	—7	3.0	20
6.	27	37	35	19	27.0	16	16	18	25	12	18.5	13
7.	30	22	34	21	27.5	13	12	15	17	11	14.0	6
8.	20	17	24	17	20.5	7	2	18	18	0	9.0	18
9.	10	22	24	9	16.5	15	22	29	30	17	23.5	13
10.	19	14	29	14	21.5	15	22	14	32	14	23.0	18
11.	14	24	24	9	16.5	15	7	16	22	5	13.5	17
12.	35	34	44	21	32.5	23	18	27	29	15	22.0	14
13.	21	18	35	18	26.5	17	18	18	35	16	25.5	19
14.	16	9	19	9	14.0	10	—8	12	18	—11	3.5	29
15.	9	11	14	8	11.0	6	10	2	12	2	7.0	10
16.	14	19	22	12	17.0	10	0	18	21	—4	8.5	25
17.	20	28	33	19	26.0	14	23	23	32	16	24.0	16
18.	27	36	40	23	31.5	17	15	16	25	11	18.0	14
19.	37	35	39	34	36.5	5	17	27	34	13	23.5	21
20.	31	35	48	29	38.5	19	26	36	37	25	31.0	12
21.	32	33	45	30	37.5	15	35	35	44	33	38.5	11
22.	33	24	34	24	29.0	10	34	26	35	27	35.0	8
23.	11	18	26	10	18.0	16	25	32	35	25	30.0	10
24.	20	21	25	16	20.5	9	26	32	42	26	34.0	16
25.	14	6	.....	6	.....	.....	19	36	42	15	28.5	27
26.	—3	8	8	—5	1.5	13	32	18	39	18	28.5	21
27.	16	22	24	8	16.0	16	14	24	30	12	21.0	18
28.	16	9	26	9	17.5	17	30	28	29	22	25.5	7
29.	2	11	13	—1	6.0	14	.....	.....	.....	.....	.....	.....
30.	9	11	21	8	14.5	13	.....	.....	.....	.....	.....	.....
31.	8	14	20	3	11.5	17	.....	.....	.....	.....	.....	.....
Means.	19.9	21.6	28.9	15.6	22.5	12.9	15.3	20.3	27.1	11.8	19.7	15.8

Meteorological Records for 1905—Temperature—Continued.

Dates.	March.						April.					
	8 A. M.	8 P. M.	Maximum.	Minimum.	Mean.	Range.	8 A. M.	8 P. M.	Maximum.	Minimum.	Mean.	Range.
1,	26	23	35	23	29.0	12	44	48	56	40	48.0	16
2,	13	21	27	10	18.5	17	38	44	55	33	44.0	22
3,	22	31	34	17	25.5	17	35	50	50	26	38.0	24
4,	31	20	38	20	29.0	18	53	53	71	26	48.5	45
5,	12	33	37	10	23.5	27	45	45	53	41	47.0	12
6,	24	30	36	24	30.0	12	36	37	45	33	39.0	12
7,	30	32	32	25	28.5	7	34	33	45	27	36.0	18
8,	34	34	37	32	34.5	5	32	34	39	27	33.0	12
9,	22	30	35	21	28.0	14	38	52	60	26	43.0	34
10,	33	26	39	26	32.5	13	53	56	73	35	54.0	38
11,	23	29	33	20	26.5	13	56	50	57	50	53.5	7
12,	25	30	41	20	30.5	21	39	46	51	37	44.0	14
13,	20	28	35	15	25.0	20	42	55	60	38	49.0	22
14,	25	27	36	22	29.0	14	40	38	55	38	46.5	17
15,	18	33	38	15	26.5	23	37	35	44	30	37.0	14
16,	29	53	56	22	39.0	34	30	30	37	22	29.5	15
17,	40	53	64	37	50.5	27	32	32	32	18	25.0	14
18,	46	58	68	37	52.5	31	33	31	37	26	31.5	11
19,	51	51	58	50	54.0	8	38	47	55	26	40.5	29
20,	41	34	52	34	43.0	18	53	57	52	40	46.0	12
21,	32	32	36	32	34.0	4	55	50	64	40	52.0	24
22,	34	40	41	32	36.5	9	36	46	58	33	43.0	20
23,	38	40	42	37	39.5	5	41	50	58	33	45.5	25
24,	43	39	46	39	42.5	7	42	55	62	33	47.5	29
25,	43	53	57	36	46.5	21	51	61	68	43	55.5	25
26,	46	47	58	33	45.5	25	58	58	69	46	57.5	23
27,	48	58	60	36	48.0	24	57	63	74	53	63.5	21
28,	50	67	76	43	59.5	33	52	64	74	44	59.0	30
29,	51	68	79	47	63.0	32	55	58	65	53	59.0	12
30,	56	47	76	47	61.5	29	53	52	59	46	52.5	13
31,	47	58	69	39	54.0	30	.....	.....	.....	.....	.....	.....
Means,	34.0	39.5	47.4	29.1	37.9	18.4	43.6	44.3	55.8	34.4	45.6	21.3

Meteorological Records for 1905—Temperature—Continued.

Dates.	May.						June.					
	8 A. M.	8 P. M.	Maximum.	Minimum.	Mean.	Range.	8 A. M.	8 P. M.	Maximum.	Minimum.	Mean.	Range.
1.	38	45	50	36	43.0	14	54	53	63	53	58.0	10
2.	46	63	70	38	54.0	32	53	57	64	47	55.5	17
3.	67	67	74	52	63.0	22	54	66	72	43	57.5	29
4.	71	79	85	56	70.5	29	58	62	65	46	55.5	19
5.	48	51	75	47	61.0	28	62	74	74	60	67.0	14
6.	55	62	63	51	57.0	12	76	59	79	59	69.0	20
7.	64	58	68	47	57.5	21	56	55	60	55	57.5	5
8.	53	56	74	40	57.0	34	52	62	66	50	58.0	16
9.	47	56	67	45	56.0	22	56	65	74	43	58.5	31
10.	44	47	56	42	49.0	14	67	67	74	57	65.5	17
11.	53	61	67	45	56.0	22	65	72	76	61	68.5	15
12.	65	65	77	56	66.5	21	68	68	81	63	72.0	18
13.	56	69	77	52	64.5	25	66	69	74	58	66.6	16
14.	63	63	69	62	65.5	7	69	76	82	55	68.5	27
15.	68	66	74	63	68.5	11	67	74	85	73	79.0	12
16.	59	59	66	56	61.0	10	73	73	81	67	74.0	14
17.	54	54	69	49	59.0	20	72	77	82	61	70.5	21
18.	54	54	57	49	57.0	8	73	74	83	74	78.5	9
19.	52	56	57	44	50.5	13	74	71	89	71	80.0	18
20.	48	50	57	43	50.0	14	77	76	87	67	77.0	20
21.	50	59	64	34	49.0	30	72	72	80	66	73.0	14
22.	58	50	68	40	54.0	28	71	71	76	62	69.0	14
23.	49	51	59	41	50.0	18	67	66	72	61	66.5	11
24.	49	53	67	35	51.0	32	62	64	72	60	66.0	12
25.	61	67	75	53	64.0	22	65	74	80	56	68.0	24
26.	64	61	67	61	64.0	6	74	62	73	62	67.5	11
27.	61	67	72	57	64.5	15	58	58	66	52	59.0	14
28.	63	68	78	56	67.0	22	58	63	68	47	57.5	21
29.	63	73	79	52	64.5	27	63	67	77	48	62.5	29
30.	59	61	73	58	65.5	15	66	74	81	53	67.0	28
31.	56	55	60	52	56.0	8						
Means,	56.1	59.7	68.2	48.8	58.6	19.4	64.9	67	75	58	66.4	17

Meteorological Records for 1905—Temperature—Continued.

Dates.	July.						August.					
	8 A. M.	8 P. M.	Maximum.	Minimum.	Mean.	Range.	8 A. M.	8 P. M.	Maximum.	Minimum.	Mean.	Range.
1,	70	64	73	64	68.5	9	60	68	64	54	59.0	10
2,	79	73	73	63	68.0	10	62	68	75	53	64.0	22
3,	66	75	83	60	71.5	23	61	69	78	52	65.0	26
4,	71	75	75	70	72.5	5	63	64	81	54	67.5	27
5,	73	71	77	68	72.5	9	69	73	77	61	69.0	16
6,	71	72	77	68	72.5	9	72	68	83	66	74.5	17
7,	74	77	80	70	75.0	10	69	72	79	62	70.5	17
8,	70	75	84	62	73.0	22	71	72	80	63	71.5	17
9,	75	73	85	63	74.0	22	66	74	79	60	69.5	19
10,	76	70	86	61	73.5	25	72	76	82	65	73.5	17
11,	73	77	83	65	74.0	18	77	72	84	69	76.5	15
12,	74	70	82	70	76.0	12	72	72	83	69	76.0	14
13,	74	67	77	67	72.0	10	73	71	78	68	73.0	10
14,	72	72	77	60	68.5	17	66	69	71	67	69.0	4
15,	72	73	82	63	72.5	19	67	71	80	63	71.5	17
16,	67	73	81	56	68.5	25	60	62	71	55	63.0	16
17,	76	81	88	71	79.5	17	61	61	70	55	62.5	15
18,	77	80	88	70	79.0	18	62	64	70	50	60.0	20
19,	78	70	80	70	75.0	10	61	65	67	57	62.0	10
20,	73	73	80	67	73.5	13	61	67	74	58	66.0	16
21,	67	69	78	58	68.0	20	66	73	81	56	68.5	25
22,	62	60	68	53	60.5	15	71	63	77	59	68.0	18
23,	61	63	71	59	65.0	12	65	74	83	58	70.5	25
24,	67	66	76	62	69.0	14	69	67	86	63	74.5	23
25,	63	65	71	57	64.0	14	58	63	67	58	62.5	9
26,	62	64	73	51	62.0	22	59	64	72	50	61.0	22
27,	66	68	75	52	63.5	23	61	64	70	50	60.0	20
28,	64	64	75	54	64.5	21	56	67	74	45	59.5	29
29,	66	63	72	62	67.0	10	67	70	77	60	68.5	17
30,	63	66	69	58	63.5	11	70	76	79	65	72.0	14
31,	64	63	69	61	65.0	8	63	66	76	61	68.5	15
Means,	69.9	70.1	77.7	62.4	70.0	15.3	65.5	68.5	76.4	58.0	67.6	18.4

Meteorological Records for 1905—Temperature—Continued.

Dates.	September.						October.					
	8 A. M.	8 P. M.	Maximum.	Minimum.	Mean.	Range.	8 A. M.	8 P. M.	Maximum.	Minimum.	Mean.	Range.
1.	63	.....	76	55	65.5	21	67	69	82	50	66.0	32
2.	64	66	66	57	61.5	9	62	65	81	.....	.....	.....
3.	69	73	82	67	74.5	15	55	59	72	.....	.....	.....
4.	65	63	73	63	68.0	10	61	65	65	52	58.5	13
5.	58	60	67	49	58.0	18	64	61	75	57	66.0	18
6.	61	67	67	49	58.0	18	50	47	61	43	52.0	18
7.	59	64	73	52	62.5	21	42	52	61	33	47.0	28
8.	64	62	72	56	64.0	16	53	58	71	38	54.5	33
9.	57	64	73	48	60.5	25	56	65	79	47	63.0	32
10.	54	66	68	50	59.0	18	52	65	69	49	59.0	20
11.	60	66	66	60	63.0	6	59	44	64	44	54.0	20
12.	63	65	74	61	67.5	13	37	41	44	37	40.5	7
13.	65	54	71	54	62.5	17	41	55	59	36	47.5	23
14.	46	65	71	54	62.5	17	58	61	74	54	64.0	20
15.	53	65	67	62	64.5	5	55	65	73	41	57.0	32
16.	62	53	63	40	51.5	23	62	52	68	52	60.0	16
17.	68	61	61	46	53.5	15	42	56	61	34	47.5	27
18.	66	73	82	61	71.5	21	55	68	70	53	61.5	17
19.	65	74	84	63	73.5	21	62	61	70	59	64.5	11
20.	70	62	73	62	67.5	11	60	43	63	43	53.0	20
21.	58	62	72	48	60.0	24	38	40	41	36	38.5	5
22.	68	70	77	58	67.5	19	38	39	45	31	38.0	14
23.	59	58	70	54	62.0	16	39	41	47	35	41.0	12
24.	55	62	69	44	56.5	25	48	47	54	37	45.5	17
25.	54	48	62	48	55.0	14	45	39	47	37	42.0	10
26.	44	66	73	34	53.5	39	34	42	46	30	38.0	16
27.	46	65	79	53	66.0	26	40	46	46	39	42.5	7
28.	63	65	82	50	66.0	32	45	41	53	41	47.0	12
29.	61	68	82	50	66.0	32	33	35	42	29	35.5	13
30.	63	65	83	50	66.5	33	29	45	50	26	38.0	24
31.	.....	.....	.....	.....	.....	.....	45	46	46	43	44.5	3
Means.	60.1	63.9	72.6	53.3	62.9	19.3	49.3	52	60.6	41.6	50.5	17.9

Meteorological Records for 1905—Temperature—Continued.

Dates.	November.						December.					
	8 A. M.	8 P. M.	Maximum.	Minimum.	Mean.	Range.	8 A. M.	8 P. M.	Maximum.	Minimum.	Mean.	Range.
1,	41	33	46	31	38.5	15	12	26	31	9	20.0	22
2,	30	37	42	26	34.0	16	30	37	38	25	31.5	13
3,	35	34	38	32	35.0	6	36	33	38	32	35.0	6
4,	36	38	42	30	36.0	12	21	24	33	19	26.0	14
5,	30	43	45	26	35.5	19	27	25	29	23	26.0	6
6,	47	42	52	40	46.0	12	28	34	40	24	32.0	16
7,	40	40	43	38	40.5	5	32	40	48	31	39.5	17
8,	39	35	42	34	38.0	8	35	42	51	25	38.0	26
9,	33	33	36	32	34.0	4	31	34	43	28	35.5	15
10,	32	34	39	29	34.0	10	34	29	36	29	31.5	5
11,	37	39	49	30	39.5	19	31	38	36	25	30.5	11
12,	41	54	58	36	47.0	22	35	41	49	33	41.0	16
13,	42	37	54	36	45.0	18	32	30	42	30	36.0	12
14,	16	26	36	13	24.5	23	21	22	34	20	27.0	14
15,	27	35	36	22	29.0	14	13	23	23	12	17.5	11
16,	34	37	40	32	36.0	8	23	30	34	21	27.5	13
17,	34	38	38	31	34.5	7	16	34	43	12	27.5	31
18,	37	39	49	36	42.5	13	28	36	36	24	30.0	12
19,	29	30	40	24	32.0	16	35	36	37	34	35.5	3
20,	21	28	36	18	27.0	18	36	37	37	34	35.5	3
21,	18	33	39	15	27.0	24	38	44	44	34	39.0	10
22,	23	41	51	19	35.0	32	40	39	44	36	40.0	8
23,	41	45	56	35	45.5	21	56	32	40	31	35.5	9
24,	32	51	55	26	40.5	29	21	22	32	20	26.0	12
25,	40	38	54	39	46.5	15	24	25	26	17	21.5	9
26,	29	42	51	26	38.5	25	26	37	41	24	32.5	17
27,	33	35	43	31	37.0	12	31	40	49	27	38.0	22
28,	35	39	39	30	34.5	9	25	39	48	23	35.5	25
29,	52	40	52	38	45.0	14	40	38	46	37	41.5	9
30,	24	16	40	16	28.0	24	30	33	48	26	37.0	22
31,	.....	.....	.....	.....	.....	.....	29	30	34	26	30.0	8
Means,	33.6	37.1	44.7	29.0	36.9	15.7	29.5	33.1	39.0	25.5	32.2	13.4

Meteorological Records for 1905—Precipitation in Inches—Rain and Snow.

Dates.	January.		February.		March.		April.		May.
	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.
1.	Trace.				Trace.	Trace.			
2.	.07								
3.	.54	3.50							
4.	.08	.80			.69	6.90	.21		
5.	.03	.30	.08	.80			.06		Trace.
6.	.70	4.50	.33	3.30			.33	Trace.	.47
7.	.81	.40			.07	Trace.	.03	Trace.	
8.	Trace.	Trace.	.04	.40	.53		Trace.	Trace.	Trace.
9.	Trace.	Trace.	.28	2.80	.11				.02
10.	.05	.50	.03	.30	.04		.67		.19
11.	.30	3.00					.44		.24
12.	.29		.42	4.20					
13.	Trace.	Trace.	Trace.	Trace.					
14.					.01	.10	.05		.34
15.			Trace.	Trace.					Trace.
16.	Trace.	Trace.					.08	.80	.15
17.							Trace.	Trace.	.61
18.							.01	.10	.02
19.	Trace.				.50				
20.	Trace.		.01	.10	Trace.		.33		
21.	Trace.	Trace.			1.33		.16		
22.	.10	1.00	.04	.40					
23.									.15
24.	.12	1.20			.23				
25.	.07	.70			.25				
26.					.16		.02		1.03
27.	Trace.	Trace.							
28.	Trace.	Trace.	Trace.	Trace.					
29.							.10		
30.					.01				.34
31.	.03	.30							.15
Totals.	3.19	16 20	1.23	12.30	3.92	7.00	2.49	.90	3.34

Meteorological Records for 1905—Precipitation in Inches—(Rain and Snow)—Continued.

Dates.	June.	July.	August.	Sept.	October.		November.		December.	
	Total precipitation.	Total precipitation.	Total precipitation.	Total precipitation.	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.
1,	.11	.03					.10			
2,	.07	.44		.06	1.09				.47	Trace.
3,				.35			.09	.40	1.21	Trace.
4,	.32	Trace.	.13	.20			.61	Trace.	Trace.	Trace.
5,	.02						.02		Trace.	Trace.
6,	.81	.13	.20				.28			
7,	.65	.05					Trace.			
8,		.39	.31				.05	Trace.		
9,		.19					Trace.	Trace.	Trace.	Trace.
10,	.04	.04								
11,			Trace.	.74	.98					
12,		.14	1.17							
13,		.41	.12				.13			
14,		.41					.03	.30		
15,			.76	.03						
16,	.13						.02	Trace.	.05	Trace.
17,							.01	Trace.		
18,	.42			.50						
19,	.09	Trace.			.46				Trace.	
20,									Trace.	
21,	.47		Trace.		Trace.				1.04	
22,	.36	.38	.77						.01	
23,	Trace.	.49	.03		.02				.07	
24,	.23		.38		Trace.		.04		Trace.	Trace.
25,	.01		.34		Trace.		.02		Trace.	Trace.
26,	.25						Trace.			
27,										
28,		Trace.					.92	.30	.15	
29,		.51					.93		.35	
30,		.22					Trace.	Trace.	Trace.	Trace.
31,		.03	.07		.28				.08	.80
Totals,	3.98	3.86	4.28	1.88	2.83		2.65	1.00	3.43	.80

Meteorological Records for 1905—Dew Points (in Degrees Fahrenheit).

Dates.	January.			February.			March.			April.		
	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.
1.	37	40	38.5	15	21	18.0	26	23	24.5	30	40	35.0
2.	42	40	41.0	3	1	2.0	13	21	17.0	28	26	27.0
3.	19	11	15.0	—3	7	2.0	22	31	26.5	24	37	30.5
4.	5	15	10.0	0	6	13.0	31	20	25.5	43	49	46.0
5.	14	19	16.5	—3	12	4.5	12	30	21.0	39	39	39.0
6.	27	31	29.0	16	18	17.0	24	30	27.0	31	26	28.5
7.	30	22	26.0	12	15	13.5	27	32	29.5	29	33	31.0
8.	20	17	18.5	2	18	10.0	34	31	32.5	32	29	30.5
9.	10	22	16.0	22	26	24 0	22	.....	.....	24	37	30.5
10.	19	14	16.5	22	14	18.0	30	23	26.5	43	53	48.0
11.	14	24	19.0	7	16	11.5	23	26	24.5	54	46	50.0
12.	32	29	30.5	18	27	22.5	25	24	24.5	29	37	33.0
13.	21	18	19.5	18	18	18.0	20	28	24.0	38	43	40.5
14.	16	9	12.5	—8	12	2.0	25	27	26.0	33	.....	.....
15.	9	11	10.0	10	2	6.0	18	30	24.0	29	30	29.5
16.	14	15	14.5	0	18	9.0	29	41	35.0	24	24	24.0
17.	20	25	22.5	23	23	23.0	38	41	39.5	27	27	27.0
18.	24	31	27.5	15	16	15.5	42	42	42.0	30	25	27.5
19.	29	34	31.5	17	27	22.0	51	49	50.0	33	33	33.0
20.	31	35	33.0	26	31	28.5	39	34	36.5	38	50	44.0
21.	32	.....	.....	32	30	31.0	32	32	32.0	50	50	50.0
22.	33	24	28.5	29	26	27.5	34	35	34.5	28	30	29.0
23.	11	18	14.5	25	29	27.0	33	35	34.0	28	34	31.0
24.	20	21	20.5	26	32	29.0	41	39	40.0	33	36	34.5
25.	14	6	10.0	19	31	25.0	39	38	38.5	38	33	35.5
26.	—3	8	2.5	27	.....	.....	39	45	42.0	55	51	53.0
27.	16	22	19.0	14	24	19.0	40	40	40.0	54	51	52.5
28.	16	9	12.5	30	28	29.0	40	52	46.0	42	54	48.0
29.	2	11	6.5	.....	.....	.....	43	49	46.0	52	47	49.5
30.	9	11	10.0	.....	.....	.....	49	36	42.5	38	34	36.0
31.	8	14	11.0	.....	.....	.....	36	51	43.5	.....	.....	.....
Means.	19.1	20.2	19.4	14.8	19.6	16.9	31.5	34.5	33.2	35.9	38.1	37.0

Meteorological Records for 1905—Dew Points—Continued.

Dates.	May.			June.			July.			August.		
	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.
1,	28	30	29.0	50	51	50.5	64	62	63.0	53	60	56.5
2,	35	51	43.0	51	46	48.5	62	67	64.5	57	60	58.5
3,	54	59	56.5	44	54	49.0	64	64	64.0	56	58	57.0
4,	62	61	61.5	47	60	53.5	68	71	69.5	58	62	60.0
5,	44	47	45.5	62	67	64.5	66	70	68.0	64	67	65.5
6,	55	60	57.5	64	59	61.5	67	66	66.5	68	65	66.5
7,	50	37	43.5	56	55	55.5	68	68	68.0	63	68	65.5
8,	41	52	46.5	44	50	47.0	66	64	65.0	67	66	66.5
9,	39	40	39.5	44	53	48.5	64	67	66.5	63	67	65.0
10,	37	47	42.0	52	62	57.0	70	66	68.0	68	70	69.0
11,	45	56	50.5	62	69	65.5	69	71	70.0	71	71	71.0
12,	60	62	61.0	65	62	63.5	68	67	67.5	71	71	71.0
13,	49	52	50.5	60	59	59.5	68	64	66.0	70	70	70.0
14,	61	63	62.0	59	64	61.5	64	64	64.0	60	66	63.0
15,	62	66	64.0	62	68	65.0	64	64	64.0	66	63	64.5
16,	56	56	56.0	66	69	67.5	61	66	63.5	53	57	55.0
17,	.....	53	.....	66	70	68.0	66	71	68.5	56	54	55.0
18,	44	45	44.5	70	67	68.5	68	70	69.0	53	52	52.5
19,	44	37	40.5	70	68	69.0	71	64	67.5	50	53	51.5
20,	35	34	34.5	70	70	70.0	66	61	63.5	56	62	59.0
21,	37	39	38.0	68	71	69.5	62	63	62.5	66	61	63.5
22,	42	42	42.0	70	67	68.5	53	56	54.5	63	63	63.0
23,	43	36	39.5	62	61	61.5	61	61	61.0	62	70	66.0
24,	49	37	43.0	60	61	60.5	62	56	59.0	66	67	66.5
25,	44	52	48.0	60	63	61.5	55	51	53.0	58	58	58.0
26,	54	61	57.5	65	55	60.0	55	54	54.5	50	54	52.0
27,	58	61	59.5	51	49	50.0	58	60	59.0	54	54	54.0
28,	53	53	53.0	49	55	52.0	57	61	59.0	53	59	56.0
29,	55	61	58.0	55	61	58.0	64	61	62.5	61	62	61.5
30,	56	58	57.0	60	65	62.5	61	60	60.5	62	69	65.5
31,	49	55	52.0	.....	.....	.....	57	56	56.5	58	58	58.0
Means,	48.0	50.4	49.2	58.8	61.0	59.9	63.5	63.4	63.5	60.5	62.5	61.5

Meteorological Records for 1905—Dew Points—Continued.

Dates.	September.			October.			November.			December.		
	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.
1.	55	62	58.5	59	61	60.0	34	21	27.5	12	23	17.5
2.	61	66	63.5	60	63	61.5	24	23	23.5	30	37	33.5
3.	68	67	67.5	48	48	48.0	27	34	30.5	36	30	33.0
4.	62	55	58.5	48	51	49.5	25	33	29.0	18	21	19.5
5.	53	55	54.0	54	42	48.0	27	39	33.0	24	22	23.0
6.	54	53	53.5	44	39	41.5	45	38	41.5	28	29	28.5
7.	56	57	56.5	38	44	41.0	35	35	35.0	29	30	29.5
8.	57	57	57.0	45	53	49.0	32	30	31.0	27	33	30.0
9.	54	56	55.0	51	60	55.5	28	30	29.0	28	34	31.0
10.	52	60	56.0	50	59	54.5	29	31	30.0	29	26	27.5
11.	60	63	61.5	57	40	48.5	29	29	29.0	28	36	32.0
12.	56	62	59.0	32	34	33.0	31	28	29.5	32	31	31.5
13.	60	46	53.0	31	43	37.0	35	35	35.0	27	24	25.5
14.	37	43	40.0	47	50	48.5	12	20	16.0	21	19	20.0
15.	45	52	48.5	52	55	53.5	21	35	28.0	13	20	16.5
16.	55	60	57.5	50	42	46.0	29	32	30.5	20	30	25.0
17.	60	62	61.0	39	47	43.0	29	31	30.0	16	19	17.5
18.	66	70	68.0	54	62	58.0	32	32	32.0	22	34	28.0
19.	65	71	68.0	59	61	60.0	26	30	28.0	32	34	33.0
20.	67	53	60.0	57	36	46.5	21	22	21.5	31	32	31.5
21.	55	52	53.5	33	27	30.0	18	21	19.5	38	40	39.0
22.	57	57	57.0	31	37	34.0	20	25	22.5	30	34	32.0
23.	44	42	43.0	34	34	34.0	36	36	36.0	56	27	41.5
24.	48	45	46.5	40	43	41.5	32	41	36.5	18	19	18.5
25.	44	37	40.5	43	34	38.5	33	33	33.0	24	22	23.0
26.	40	40	40.0	26	33	29.5	26	35	30.5	23	29	26.0
27.	42	52	47.0	35	42	38.5	28	27	27.5	28	30	29.0
28.	58	53	55.5	43	34	38.5	27	37	32.0	22	39	30.5
29.	54	58	56.0	28	27	27.5	52	33	42.5	40	38	39.0
30.	55	51	53.0	26	45	35.5	17	12	14.5	30	33	31.5
31.	.....	.....	.....	39	44	41.5	.....	.....	.....	29	27	28.0
Means.	54.7	55.2	54.9	43.6	44.8	44.2	28.7	30.3	29.5	27.1	29.1	28.1

Meteorological Reports for 1905—Relative Humidity (in Per Cent).

Dates.	January.			February.			March.			April.		
	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.
1.	78	73	75.5	100	100	100.0	100	100	100.0	70	73	71.5
2.	79	100	89.5	100	100	100.0	100	100	100.0	66	49	57.5
3.	100	100	100.0	100	100	100.0	100	100	100.0	64	61	62.5
4.	100	100	100.0	100	100	100.0	100	100	100.0	70	87	78.5
5.	100	100	100.0	100	100	100.0	100	90	95.0	78	78	78.0
6.	100	91	95.5	100	100	100.0	100	100	100.0	82	65	73.5
7.	100	100	100.0	100	100	100.0	89	100	94.5	81	100	90.5
8.	100	100	100.0	100	100	100.0	100	90	95.0	100	81	90.5
9.	100	100	100.0	100	89	94.5	100	.....	.....	57	57	57.0
10.	100	100	100.0	100	100	100.0	90	88	89.0	70	88	79.0
11.	100	100	100.0	100	100	100.0	100	89	94.5	94	87	90.5
12.	91	81	86.0	100	100	100.0	100	79	89.5	67	72	69.5
13.	100	100	100.0	100	100	100.0	100	100	100.0	84	65	74.5
14.	100	100	100.0	100	100	100.0	100	100	100.0	76	.....	.....
15.	100	100	100.0	100	100	100.0	100	90	95.0	74	81	77.5
16.	100	85	92.5	100	100	100.0	100	63	81.5	79	79	79.0
17.	100	89	94.5	100	100	100.0	92	63	77.5	80	80	80.0
18.	89	82	85.5	100	100	100.0	85	56	70.5	90	79	84.5
19.	74	91	82.5	100	100	100.0	100	93	96.5	83	59	71.0
20.	100	100	100.0	100	82	91.0	92	100	96.0	58	77	67.5
21.	100	.....	.....	91	81	86.0	100	100	100.0	82	100	91.0
22.	100	100	100.0	81	100	90.5	100	84	92.0	73	52	62.5
23.	100	100	100.0	100	90	95.0	83	84	83.5	60	55	57.5
24.	100	100	100.0	100	100	100.0	92	100	96.0	69	49	59.0
25.	100	100	100.0	100	82	91.0	85	58	71.5	62	35	48.5
26.	100	100	100.0	80	.....	.....	72	93	82.5	89	78	83.5
27.	100	100	100.0	100	100	100.0	73	51	62.0	88	64	76.0
28.	100	100	100.0	100	100	100.0	68	58	63.0	69	70	69.5
29.	100	100	100.0	.....	.....	.....	74	56	62.0	88	67	77.5
30.	100	100	100.0	.....	.....	.....	77	66	71.5	58	51	54.5
31.	100	100	100.0	.....	.....	.....	66	78	72.0	.....	.....	.....
Means,	97.1	96.4	96.7	98.3	97.2	98.1	91.5	84.1	87.7	75.4	70.3	72.8

Meteorological Records for 1905—Relative Humidity—Continued.

Dates.	May.			June.			July.			August.		
	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.
1.	66	57	61.5	88	94	91.0	81	95	88.0	78	76	77.0
2.	66	64	65.0	94	66	80.0	57	82	69.5	84	76	80.0
3.	62	76	69.0	70	66	68.0	95	70	82.5	84	67	75.5
4.	72	53	62.5	67	95	81.0	91	87	89.0	84	95	89.5
5.	86	87	86.5	100	78	89.0	78	95	86.5	86	82	84.0
6.	100	95	97.5	66	100	83 0	86	82	84.0	86	90	88.0
7.	60	46	53.0	100	100	100.0	82	74	78.0	81	86	83.5
8.	63	58	60.5	75	64	69.5	86	70	78.0	86	82	84.0
9.	72	55	63.5	65	65	65.0	70	82	76.0	90	78	84.0
10.	78	100	89.0	58	85	71.5	82	86	84.0	86	82	84.0
11.	75	84	79.5	90	91	90.5	86	83	84.5	83	95	89.0
12.	85	85	85.0	90	81	85.5	82	90	86.0	95	95	95.0
13.	77	55	66.0	80	72	76.0	82	90	86.0	91	95	93.0
14.	95	100	97.5	72	66	69.0	77	77	77.0	80	90	85.0
15.	81	100	90.5	85	82	83.5	77	73	75.0	95	77	86.0
16.	89	89	89.0	78	86	82.0	80	78	79.0	78	84	81.0
17.	.....	88	.....	82	78	80.0	70	72	71.0	84	78	81.0
18.	70	86	78.0	91	78	84.5	74	72	73.0	74	65	69.5
19.	75	50	62.5	86	91	88.5	79	81	80.0	68	65	66.5
20.	60	55	57.5	78	82	80.0	78	65	71.5	84	85	84.5
21.	61	47	54.0	86	95	90.5	85	81	83.0	100	65	82.5
22.	56	74	65.0	95	86	90.5	74	71	72.5	77	100	88.5
23.	80	56	68.0	85	85	85.0	100	95	97.5	90	86	88.0
24.	100	46	73.0	95	90	92.5	85	71	78.0	90	100	95.0
25.	54	58	56.0	85	70	77.5	74	61	67.5	100	84	92.0
26.	70	100	85.0	74	79	76.5	79	70	74.5	72	70	71.0
27.	89	80	84.5	78	72	75.0	75	76	75.5	78	70	74.0
28.	69	58	63.5	72	74	73.0	79	90	84.5	88	76	82.0
29.	74	65	69.5	74	80	77.0	95	95	95.0	80	77	78.5
30.	89	89	89.0	80	74	77.0	95	80	87.5	77	78	77.5
31.	77	100	88.5	.....	.....	.....	79	79	79.0	84	75	79.5
Means.	75	72.8	73.6	81.3	80.8	81.1	81.1	79.8	80.4	84.3	81.4	82.9

Meteorological Records for 1905—Relative Humidity—Continued.

Dates.	September.			October.			November.			December.		
	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.
1,	74	85	79.5	76	76	76.0	76	62	69.0	100	88	94.0
2,	90	100	95.0	95	95	95.0	79	56	67.5	100	100	100.0
3,	95	82	88.5	76	67	71.5	72	100	86.0	100	90	95.0
4,	90	74	82.0	63	61	62.0	64	83	73.5	86	87	86.5
5,	83	84	83.5	70	49	59.5	89	85	87.0	89	88	88.5
6,	78	74	76.0	80	72	76.0	93	84	88.5	100	81	90.5
7,	89	79	84.0	84	75	79.5	84	84	84.0	90	68	79.0
8,	79	84	81.5	75	83	79.0	75	81	78.0	72	69	70.5
9,	88	74	81.0	82	85	83.5	80	90	85.0	90	100	95.0
10,	94	80	87.0	94	80	87.0	90	90	90.0	81	89	85.0
11,	100	90	95.0	94	85	89.5	74	67	70.5	90	100	95.0
12,	79	90	84.5	82	76	79.0	68	37	52.5	91	68	79.5
13,	85	76	80.5	68	65	66.5	77	91	84.0	80	79	79.5
14,	72	70	71.0	67	68	67.5	84	76	80.0	100	86	93.0
15,	75	73	74.0	88	70	79.0	77	100	88.5	100	87	93.5
16,	79	85	82.0	64	69	66.5	81	82	81.5	87	100	93.5
17,	76	90	83.0	92	71	81.5	81	75	78.0	100	53	76.5
18,	100	91	95.5	94	81	87.5	82	75	78.5	78	91	84.5
19,	100	91	95.5	89	100	94.5	89	100	94.5	91	91	91.0
20,	90	74	82.0	89	77	83.0	100	78	89.0	82	82	82.0
21,	89	69	79.0	83	59	71.0	100	62	81.0	100	85	92.5
22,	67	61	64.0	75	92	83.5	87	53	70.0	68	83	75.5
23,	57	56	56.5	83	76	79.5	84	71	77.5	100	80	90.0
24,	76	54	65.0	73	86	79.5	100	69	84.5	86	86	86.0
25,	70	66	68.0	92	83	87.5	76	83	79.5	100	88	94.0
26,	85	68	76.5	72	69	70.5	89	77	83.0	88	74	81.0
27,	85	61	73.0	84	85	84.5	80	72	76.0	90	68	79.0
28,	84	65	74.5	92	76	84.0	72	92	82.0	88	100	94.0
29,	78	71	74.5	80	72	76.0	100	76	88.0	100	100	100.0
30,	74	61	67.5	89	100	94.5	75	84	79.5	100	100	100.0
31,	.....	.....	.....	78	93	85.5	.....	.....	.....	100	89	94.5
Means,	82.7	75.9	79.3	81.4	77.3	79.3	82.6	77.8	80.2	91.2	85.5	88.3

Meteorological Records for 1905—Cloudiness (on Scale of 10).

Dates.	January.			February.			March.			April.		
	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.
1,	2	0	1.0	9	0	4.5	10	10	10.0	2	8	5.0
2,	9	10	9.5	0	0	0	0	0	0	1	0	.5
3,	10	10	10.0	0	0	0	9	10	9.5	0	10	5.0
4,	0	10	5.0	0	0	0	10	0	5.0	2	10	6.0
5,	10	10	10.0	0	10	5.0	0	0	0	2	10	6.0
6,	10	10	10.0	10	10	10.0	0	0	0	9	2	5.5
7,	10	10	10.0	8	0	4.0	10	10	10.0	1	10	5.5
8,	5	3	4.0	5	10	7.5	10	10	10.0	0	1	0.5
9,	4	10	7.0	10	10	10.0	2	10	6.0	0	0	0
10,	2	2	2.0	10	5	7.5	9	0	4.5	6	9	7.5
11,	10	10	10.0	2	8	5.0	10	0	5.0	8	8	8.0
12,	10	10	10.0	10	10	10.0	0	5	2.5	0	8	4.0
13,	10	9	9.5	10	2	6.0	0	0	0	2	1	1.5
14,	8	0	4.0	0	2	1.0	5	8	6.5	3	8	5.5
15,	0	8	4.0	2	2	2.0	0	1	0.5	0	9	4.5
16,	9	1	5.0	3	5	4.0	6	2	4.0	6	5	5.5
17,	8	0	4.0	8	8	8.0	1	2	1.5	4	7	5.5
18,	9	9	9.0	2	0	1.0	0	1	5	10	2	6.0
19,	9	10	9.5	0	6	3.0	10	3	6.5	0	4	2.0
20,	2	9	5.5	10	10	10.0	5	10	7.5	3	6	4.5
21,	10	10	10.0	10	0	5.0	10	10	10.0	8	9	8.5
22,	10	10	10.0	10	10	10.0	10	10	10.0	1	1	1.0
23,	4	10	7.0	10	10	10.0	10	10	10.0	0	0	0
24,	10	10	10.0	0	0	0	10	10	10.0	0	0	0
25,	10	5	7.5	0	10	5.0	1	0	.5	0	0	0
26,	5	2	3.5	1	2	1.5	0	8	4.0	10	6	8.0
27,	8	10	9.0	0	0	0	0	0	0	2	8	5.0
28,	10	0	5.0	10	8	9.0	4	2	3.0	0	10	5.0
29,	0	9	4.5	.....	.....	.....	0	0	0	10	8	9.0
30,	1	0	.5	.....	.....	.....	8	0	4.0	4	5	4.5
31,	10	0	5.0	.....	.....	.....	0	0	0	.....	.....	.....
Means,	6.9	6.7	6.8	5.0	4.9	5.0	4.8	4.3	4.6	3.1	5.5	4.3

Meteorological Records—Cloudiness—Continued.

Dates.	May.			June.			July.			August.		
	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.
1.	0	0	0	10	2	6.0	8	10	9.0	0	4	2.0
2.	9	2	5.5	8	1	4.5	9	4	6.5	0	2	1.0
3.	9	2	5.5	0	1	.5	9	1	5.0	0	2	1.0
4.	0	4	2.0	3	9	6.0	10	10	10.0	0	10	5.0
5.	10	10	10.0	10	10	10.0	9	10	9.5	2	6	4.0
6.	10	8	9.0	9	10	9.5	10	4	7.0	1	1	1.0
7.	0	0	0	10	10	10.0	9	8	8.5	0	7	3.5
8.	0	2	1.0	8	1	4.5	0	8	4.0	1	1	1.0
9.	1	8	4.5	10	4	7.0	0	3	1.5	6	.....	.....
10.	9	10	9.5	0	10	5.0	0	2	1.0	10	2	6.0
11.	10	10	10.0	6	10	8.0	9	5	7.0	0	6	3.0
12.	4	5	4.5	10	6	8.0	5	8	6.5	4	8	6.0
13.	1	4	2.5	4	1	2.5	5	9	7.0	10	5	7.5
14.	10	8	9.0	0	0	0	0	9	4.5	2	10	6.0
15.	6	10	8.0	0	3	1.5	1	1	1.0	6	8	7.0
16.	10	9	9.5	9	4	6.5	0	1	.5	9	4	6.5
17.	4	8	6.0	8	4	6.0	0	1	.5	4	1	2.5
18.	3	2	2.5	9	9	9.0	0	1	.5	0	0	0
19.	6	3	4.5	2	3	2.5	0	3	1.5	8	8	8.0
20.	0	0	0	1	10	5.5	0	1	.5	10	0	5.0
21.	0	0	0	10	10	10.0	5	2	3.5	10	2	6.0
22.	0	10	5.0	9	9	9.0	7	10	8.5	0	10	5.0
23.	0	0	0	10	10	10.0	9	9	9.0	6	5	5.5
24.	10	2	6.0	10	2	6.0	5	3	4.0	0	10	5.0
25.	0	4	2.0	8	2	5.0	1	0	.5	10	4	7.0
26.	9	9	9.0	8	8	8.0	1	1	1.0	0	1	.5
27.	5	5	5.0	1	0	.5	0	7	3.5	0	2	1.0
28.	3	2	2.5	0	1	.5	2	1	1.5	1	10	5.5
29.	0	4	2.0	0	1	.5	10	10	10.0	5	1	3.0
30.	10	8	9.0	0	4	2.0	10	3	6.5	7	10	8.5
31.	8	10	9.0	.....	.....	.....	8	5	6.5	3	5	4.0
Means,	4.7	5.2	4.9	5.8	5.2	5.5	4.6	4.8	4.7	3.7	4.8	4.2

Meteorological Records—Cloudiness—Continued.

Dates.	September.			October.			November.			December.		
	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.	8 A. M.	8 P. M.	Mean.
1.	8	2	5.0	0	0	0	7	8	7.5	0	2	1.0
2.	10	8	9.0	8	0	4.0	1	0	.5	10	10	10.0
3.	9	8	8.5	5	0	2.5	9	10	9.5	10	10	10.0
4.	0	1	.5	0	0	0	5	8	6.5	9	10	9.5
5.	0	2	1.0	0	0	0	2	10	6.0	10	8	9.0
6.	0	1	.5	0	0	0	10	9	9.5	8	2	5.0
7.	0	5	2.5	0	0	0	9	10	9.5	2	0	1.0
8.	2	0	1.0	0	0	0	9	10	9.5	8	1	4.5
9.	0	0	0	0	0	0	10	9	9.5	10	10	10.0
10.	10	10	10.0	0	10	5.0	4	8	6.0	10	8	9.0
11.	10	10	10.0	10	8	9.0	1	0	.5	1	2	1.5
12.	6	0	3.0	8	8	8.0	0	4	2.0	1	0	.5
13.	0	0	0	2	0	1.0	10	10	10.0	5	4	4.5
14.	0	0	0	1	0	.5	0	1	.5	2	0	1.0
15.	8	9	8.5	1	9	5.0	7	2	4.5	10	10	10.0
16.	2	4	3.0	3	0	1.5	10	10	10.0	10	0	5.0
17.	8	10	9.0	1	2	1.5	9	0	4.5	0	0	0
18.	10	0	5.0	9	10	9.5	1	1	1.0	10	10	10.0
19.	4	0	2.0	9	10	9.5	2	0	1.0	10	10	10.0
20.	9	0	4.5	9	10	9.5	1	0	.5	10	10	10.0
21.	0	0	0	3	2	2.5	0	0	0	10	10	10.0
22.	0	0	0	6	10	8.0	2	0	1.0	9	0	4.5
23.	0	0	0	5	1	3.0	2	0	1.0	10	10	10.0
24.	0	0	0	6	8	7.0	2	2	2.0	2	0	1.0
25.	0	0	0	10	10	10.0	4	0	2.0	8	10	9.0
26.	0	0	0	0	.....	.....	9	1	5.0	2	0	1.0
27.	4	2	3.0	10	10	10.0	4	0	2.0	2	0	1.0
28.	0	0	0	9	0	4.5	10	10	10.0	2	10	6.0
29.	0	0	0	1	0	.5	10	5	7.5	9	10	9.5
30.	0	0	0	2	6	4.0	10	0	5.0	10	0	5.0
31.	.....	.....	.....	9	10	9.5	.....	.....	.....	10	6	8.0
Means,	**3.3**	**2.4**	**2.9**	**4.1**	**4.1**	**4.2**	5.3	4.3	4.8	6.8	5.3	6.0

Meteorological Records for 1905—Wind.

Dates.	January. Direction.		February. Direction.		March. Direction.		April. Direction.		May Direction.		June Direction.	
	8 A. M.	8 P. M.	8 A. M.	8 P. M.	8 A. M.	8 P. M.	8 A. M.	8 P. M.	8 A. M.	8 P. M.	8 A. M.	8 P. M.
1,	W	0	0	W	0	N	N	N	W	W	E	0
2,	0	W	W	W	NW	N	N	N	0	0	N	NW
3,	N	E	W	0	W	0	0	S	0	0	N	0
4,	W	W	0	N	N	N	0	SW	0	4	S	0
5,	S	W	0	N	0	0	W	N	SE	0	0	NW
6,	S	0	0	W	N	0	W	NW	0	0	SW	N
7,	W	W	W	N	S	0	W	0	W	W	E	0
8,	W	W	NW	N	0	N	N	NW	0	0	NW	W
9,	0	SE	0	0	0	0	W	6	S	W	E	E
10,	W	W	W	W	6	N	W	0	0	0	E	0
11,	0	W	0	0	0	0	0	W	0	0	SE	0
12,	S	NW	0	0	0	NW	NE	0	W	0	0	NW
13,	W	N	W	W	0	N	0	0	N	0	W	0
14,	W	W	W	S	N	0	N	N	0	0	0	0
15,	S	SW	0	W	0	0	N	N	S	W	0	0
16,	S	S	W	W	W	W	W	W	0	0	N	S
17,	W	S	0	W	0	0	W	W	0	0	SE	SE
18,	W	SW	W	N	0	W	SW	NW	W	W	S	S
19,	W	W	0	0	0	0	S	0	W	W	W	W
20,	W	0	0	W	0	NE	0	N	W	W	0	0
21,	0	S	N	N	E	0	W	W	N	0	SW	NW
22,	W	W	SW	E	0	0	NW	W	0	N	0	0
23,	0	N	0	W	0	S	0	W	0	0	N	N
24,	0	0	NE	0	S	0	0	W	0	S	N	N
25,	W	NW	0	0	W	0	0	0	W	W	S	S
26,	NW	W	W	W	0	0	0	0	S	0	SW	NW
27,	W	W	W	0	0	0	0	N	N	0	NW	NW
28,	W	W	W	W	0	0	0	0	N	0	N	0
29,	0	0	.....	.....	0	S	S	W	0	0	0	0
30,	0	0	.....	.....	0	W	SW	W	NE	0	N	N
31,	E	0	.....	.....	0	0	.....	.....	NE	0	.....	.....
Prevailing direction, ...	W	W	W	W	N & W	N	W	W	W	W	N	NW

Meteorological Records for 1905—Wind—Continued.

Dates.	July. Direction.		August. Direction.		September. Direction.		October. Direction.		November. Direction.		December. Direction.	
	8 A. M.	8 P. M.	8 A. M.	8 P. M.	8 A. M.	8 P. M.	8 A. M.	8 P. M.	8 A. M.	8 P. M.	8 A. M.	8 P. M.
1,	NE	SE	N	W	0	0	0	NW	W	NW	E	SW
2,	E	S	0	W	E	SE	0	W	NW	NW	SW	0
3,	N	0	N	0	SE	0	NW	N	SW	0	0	NW
4,	SE	S	0	0	0	NW	W	W	W	W	W	W
5,	S	E	0	SW	0	S	W	NW	S	0	W	0
6,	S	S	NE	W	W	W	N	0	0	W	W	W
7,	S	S	0	0	W	0	0	0	W	0	W	W
8,	W	W	0	0	W	0	0	0	W	W	0	0
9,	0	0	0	SW	0	0	0	0	W	W	0	0
10,	0	0	0	S	0	S	0	SE	NW	NW	N	N
11,	0	S	NW	0	S	0	SE	N	S	0	NW	NW
12,	S	SW	E	0	W	0	N	E	W	W	0	W
13,	SE	0	0	0	S	E	NW	SW	W	NW	W	0
14,	W	0	E	SE	NE	0	S	0	0	0	0	E
15,	N	0	0	N	SE	S	0	SE	S	0	E	NE
16,	N	0	N	0	E	0	W	W	0	NW	0	0
17,	W	S	N	0	S	0	E	W	W	0	0	SW
18,	E	0	0	SW	0	W	SW	SW	NW	0	SW	W
19,	N	0	N	S	0	0	SW	SW	0	0	0	0
20,	NW	W	0	0	SE	0	SW	W	0	N	0	E
21,	0	N	0	W	N	0	NW	W	0	0	S	W
22,	N	E	0	S	W	W	W	W	0	0	W	W
23,	0	0	0	0	NE	W	W	W	SW	0	0	NW
24,	E	W	S	N	W	W	SW	W	S	S	W	NW
25,	NW	0	N	NW	N	NW	W	N	NW	0	W	W
26,	W	W	NW	W	NW	0	N	W	0	NW	W	W
27,	0	0	E	0	W	0	SW	W	W	0	NW	W
28,	0	SW	0	0	0	0	W	W	S	0	0	W
29,	S	0	W	NW	0	0	W	W	SW	NW	SW	SW
30,	SE	NW	W	W	0	0	W	W	NW	N	W	W
31,	NW	N	W	W	0	.....	S	S	.....	.....	W	W
Prevailing direction, ...	S	S	N	W	W	W	W	W	W	NW	W	W

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